Herbicides Commonly Used in Seed Corn Production

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Module Contents

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Introduction

Herbicides can be a very powerful tool in seed corn production as weeds tend to be more competitive with inbred plants that typically do not have the vigor and crop protection strengths of hybrids.

Excessive weed population in corn field.

Weed-free corn field.

Introduction

Complexity is added to the equation when certain inbred lines cannot handle a specific chemical chemistry that would be used in regular commercial corn production. This difference in herbicide selection creates confusion among producers and seed production representatives because they have to create herbicide programs that are sensitive to the inbred plants.

Many of the corn herbicide labels have precautionary statements regarding the herbicide use on corn inbred lines as in the examples for Status™ and Impact™.

Corn

FIELD CORN GROWN FOR GRAIN, SEED, OR SILAGE AND POPCORN

Before applying **Status** to seed corn or popcorn, verify the selectivity of **Status** on the inbred line or hybrid with your local seed corn or popcorn company (supplier). This precaution will help avoid potential injury to sensitive lines.

Per Status herbicide label. (http://www.cdms.net/ldat/ld0K2001.pdf)

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I. INFORMATION

IMPACT is a systemic postemergence herbicide for control or growth suppression of emerged broadleaf and grass weeds in field corn (grown for grain, silage or seed), popcorn (grown for ear, kernel or seed) and sweet corn (grown for ear, kernel or seed). This product may be used on conventional and herbicide resistant/tolerant corn hybrids. AMVAC has not tested all inbred lines for tolerance to **IMPACT.** Before using **IMPACT** refer to seed company recommendations for use on inbred lines of field corn, popcorn and sweet corn.

Per Impact herbicide label. (http://www.agrian.com/pdfs/Impact_Label.pdf)

Introduction

Often times, the individuals communicating to the producer on what herbicides they can use do not fully understand the herbicides themselves.

The outline and objectives of this module describe popular corn herbicides used in seed production and how they differ from other products with respect to:

1. Understanding herbicide chemical modes of action
2. Herbicide application methods used in inbred corn field
3. Herbicide crop injury symptoms
4. Rotation guidelines for corn herbicides

Detasselling female lines of corn prior to pollination.

Herbicide Site of Action

Weed management can been a struggle for seed corn producers because of the reduced options when it comes to herbicides they can use.

Glyphosate is an extremely popular tool with commercial growers as it provides excellent protection against many different weed species.

Seed growers cannot always use a broadcast application of glyphosate as some parent lines may be susceptible to it. Having the ability to understand key herbicide characteristics and principles will reduce production costs and ultimately create better growing conditions for seed production.

It is important to remember that weed control did occur before the use of glyphosate. The process may have been a little bit more labor intensive, but producers were able to obtain weed control with various modes of action.

Glyphosate made the production of row crops extremely simple…. Often times, weed control was accomplished via “one pass” herbicide programs during the early years following glyphosate introduction.

Herbicide Site of Action

Herbicides can be broken down into several different categories. One is the **mode of action** (MOA) of the herbicide which refers to the broad grouping of how an herbicide effects plant growth, such as what are the plant symptoms following an herbicide application. A second category is **site of action** (SOA) referring to the specific enzyme site or pathway that the active ingredient binds or inhibits to create the plant growth effects. In this module, site of action will be used.

An outline of popular herbicide site of action and a short classification description will be presented in the following pages.

Common site of action for seed corn production:

- Group 14, 22 – Cell Membrane Disruptors
- Group 15 – Seedling Shoot Growth Inhibitors
- Group 5, 6 – Photosynthesis II Inhibitors
- Group 27 – Pigment Inhibitors
- Group 4 – Growth Regulators
- Group 2 – ALS Inhibitors
- Group 3 – Microtubule Inhibitors

Making a post-emerge herbicide application on corn. Photo courtesy of http://farmprogress.com/story-spraying-small-weeds-saves-money-boosts-yield-9-59578

Herbicide Site of Action

Photosynthesis II Inhibitors (Groups 5, 6)

Photosynthesis inhibitors (PS II) are the most widely used herbicide in corn production. They are generally used in preemergence (PRE) weed control in inbred corn fields. Post-emergence (POE) applications can be made, if needed. Atrazine is the most common PS II herbicide used in seed production.

Several of the trade names and chemical names are:

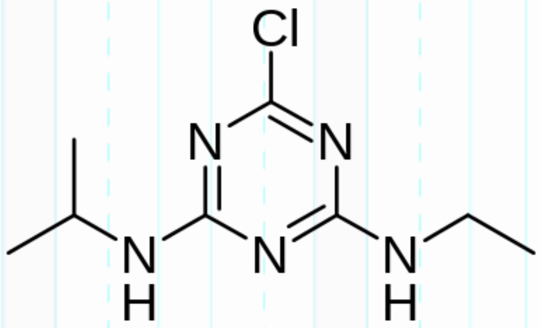
- AAtrex® 4L - Atrazine
- Sencor® - Metribuzin
- Buctril® 4EC - bromoxynil
- Linex® - Linuron

Representatives of PS II herbicides can be used in several different crops, including corn, vegetables, small grains, soybeans, and nursery crops with application methods including preplant, PRE, and POE.

Weeds controlled by the PS II herbicides can include many annual grasses and broadleaves; however, specific control is dependent on respective chemistry.

Herbicide Site of Action

Photosynthesis II Inhibitors (Groups 5, 6)



Chemical structure of atrazine.

Photosynthesis II inhibitors have low water solubility; however, atrazine has the potential to leach and pollute ground water.

PS II inhibitors bind well to soil particles.

Repeated use of PS II inhibitors may increase the potential for weed resistance. One should always rotate herbicide site of actions to help reduce weed resistance concerns.

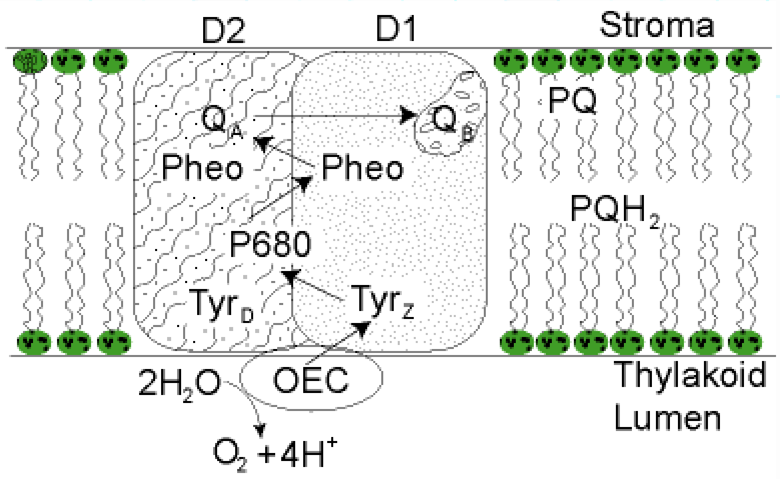
High application rates of atrazine can lead to carryover concerns to sensitive crops planted the following year. The rate of disappearance of atrazine from the soil is dependent on soil texture, soil pH and organic content, as well as atrazine rate and application timing, and rainfall.

Atrazine in the soil is taken up by the roots and moves apoplastic via the xylem in the plant. Injury symptoms appear on the lower leaves first as the herbicide moves into the vegetative part of the plant. The plant's reaction to atrazine does not occur until the plant has began photosynthesis.

Herbicides Site of Action

Photosynthesis II Inhibitors

The PS II inhibitors binds to proteins in the chloroplast of the plant cell which prevents movement of electrons in photosynthesis. There is a buildup of free radicals (reactive molecules) in the plant which promote the destruction of cell membranes. This destruction of cell membranes is what you see as leaf injury to the plant.



Foliar symptoms consist of chlorosis and necrosis beginning around leaf edges in older tissue. Chlorosis at the leaf tip will occur followed by leaf margin necrosis working from the outside to the inside of the leaf. Chemical binding sites become influenced which results in a disruption of the photosynthesis process. Secondary compounds are produced that promote the death of plant tissue.

Effects can be observed within a few days; however, complete death may take upwards of a week depending on plant size and environmental conditions.

Herbicide Site of Action

Photosynthesis II Inhibitor Injury

With foliar applications of atrazine, chlorosis initiates at leaf tips and progresses toward margins on older leaves. Older (lower) leaves generally absorb more herbicide as they are larger at the time of application.

Sunshine promotes the progression of chlorosis.

Interveinal activity follows as symptoms develop and mature.

Corn is typically safe as it is able to metabolize the chemical to acceptable levels. However, over application can stress the plant and it will begin to show standard herbicide symptoms.

With soybeans, atrazine injury will only be visible after the first leaves emerge and will be leaf "cupping". Cotyledons will not show symptoms.

Leaf burn from a post-emergence application of Atrazine.
http://fyi.uwex.edu/weedsci/files/2010/11/PhotoACorn1.jpg

Leaf cupping from dicamba drift.
Courtesy of University of Missouri.
http://extension.missouri.edu/explore/images/ipm1007growth05.jpg

Herbicide Site of Action

Photosynthesis II Inhibitor Injury

While there is good control of grasses, grasses are generally the first to “escape” treatment… control with smaller broadleaves is adequate.

Long residue… Typically apply PRE and follow POE as needed. POE applications are very common in seed production.

Leaf burn from a post-emergence application of Atrazine. http://docs.mncia.org/public/fieldservices/Herbicide_Injury_Photosynthetic_Inhibitors.pdf

Herbicide Site of Action

Cell Membrane Disruptors (Group 22, 14)

Cell membrane disruptors target the growing points of affected plants. In seed production, they are primarily used in preemergence applications as a burndown.

Several of the trade names and chemical names are:

- Gramoxone® - Paraquat
- Cobra® - Lactofen
- Valor ® - Flumioxazin
- Aim® EC - Carfentrazone

Variance in chemistry allows producers to apply cell membrane disruptors post-emergence. These formulations are not typical for seed corn production, but can play an extremely helpful part in keeping seed fields clean during other crop rotations.

Herbicide Site of Action

Cell Membrane Disruptors

Cell membrane disruptors have a very low water solubility and rapidly breakdown once they come in contact with the soil. This characteristic promotes the use of disruptors as a preemergence burndown.

Care should be taken when applying cell membrane disruptors as many formulations are non–selective.

paraquat

$$\text{Paraquat}^{+2} + \text{PSI } (e^{-}) \longrightarrow \text{Paraquat}^{*+}$$

$$\text{Paraquat}^{*+} + O_2 \longrightarrow \text{Paraquat}^{+2} + O_2^{*-}$$

$$2H^{+} + O_2^{*-} + O_2^{*-} \xrightarrow{\text{SOD}} H_2O_2 + O_2$$

Hydroxyl Radical

$$H_2O_2 + O_2^{*-} \longrightarrow O_2 + OH^{*} + OH^{-}$$

$$\text{Paraquat}^{*+} + H_2O_2 \longrightarrow \text{Paraquat}^{+2} + OH^{*} + OH^{-}$$

$$H^{+} + Fe^{+} + H_2O_2 \longrightarrow OH^{*} + Fe^{+3} + H_20$$

Pathway of Paraquat activity in a plant cell as it affects the production of hydroxyl radicals which are highly reactive and are involved in the destruction of cell membranes.

There are two primary families of disruptors.

1) Bipyridyliums – foliar applied
2) Diphenyl ethers – soil and foliar applied

Herbicide resistance is possible with multiple applications, but is unlikely if combining with other sites of action.

Herbicides Site of Action

Cell Membrane Disruptors

Cell membrane disruptors create rapid interference of cell membranes to promote fast and efficient elimination of target species. The herbicide binds to proteins that create free radicals. These free radicals limit electron transport will leads to cell death. These reactions occur naturally, but do so at significantly lower rates.

Tissue symptoms initially appear as "water soaked" lesions on leaf tissue. This is a direct result of the cell membranes "leaking" as they continue to break down. Necrosis starts in the older tissue and settles into newer growth as it's translocated throughout the plant.

Effects can be observed within several hours of application. Complete death may delayed if leaf coverage is marginal.

Water soaked lesions on a corn leaf following Paraquat application. Courtesy of University of Missouri.
http://extension.missouri.edu/explore/images/ipm1007cell03.jpg

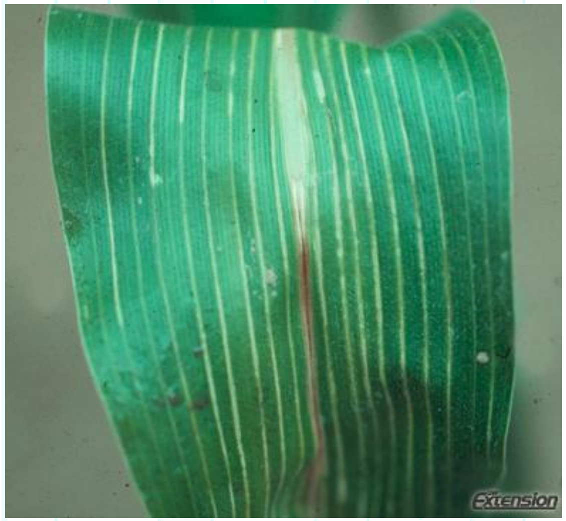
Herbicide Site of Action

Cell Membrane Disruptor Injury

Classic cell membrane symptoms can be identified by the yellowing and bronzing of leaf tissue. Spotting or “Speckling” may occur is application coverage is marginal. Sunlight and warm temperatures expedite chlorosis and eventual necrosis.

In addition to leaf spotting, discoloration or “purpling” may show up on the mid-rib or between leaf veins.

Cell Membrane Injury - https://www.btny.purdue.edu/Extension/Weeds/HerbInj2/Img/Large/Resource.JPG



Flexstar carryover in corn - http://fyi.uwex.edu/weedsci/1644-2/

Herbicide Site of Action

Amino Acid - ALS Inhibitors (Group 2) – Branched Chain

ALS inhibitors hinder the production of branched chain amino acids that are imperative for protein synthesis and plant growth. These herbicide formulations were very popular before the release of glyphosate resistant crops.

Several of the trade names and chemical names are:

- Resolve® - Rimsulfuron
- Permit® - Halosulfuron
- Classic® - Chlorimuron
- Accent® Q - Nicosulfuron

Weeds controlled with ALS inhibitors are broad and dependant on herbicide active ingredient. Applications can be made soil applied or post-emergence.

Usage in seed production has declined due to resistance issues, but remain common in regional areas where control is efficient.

DuPont™ Accent® Q herbicide

CLASSIC® HERBICIDE

Permit® HERBICIDE

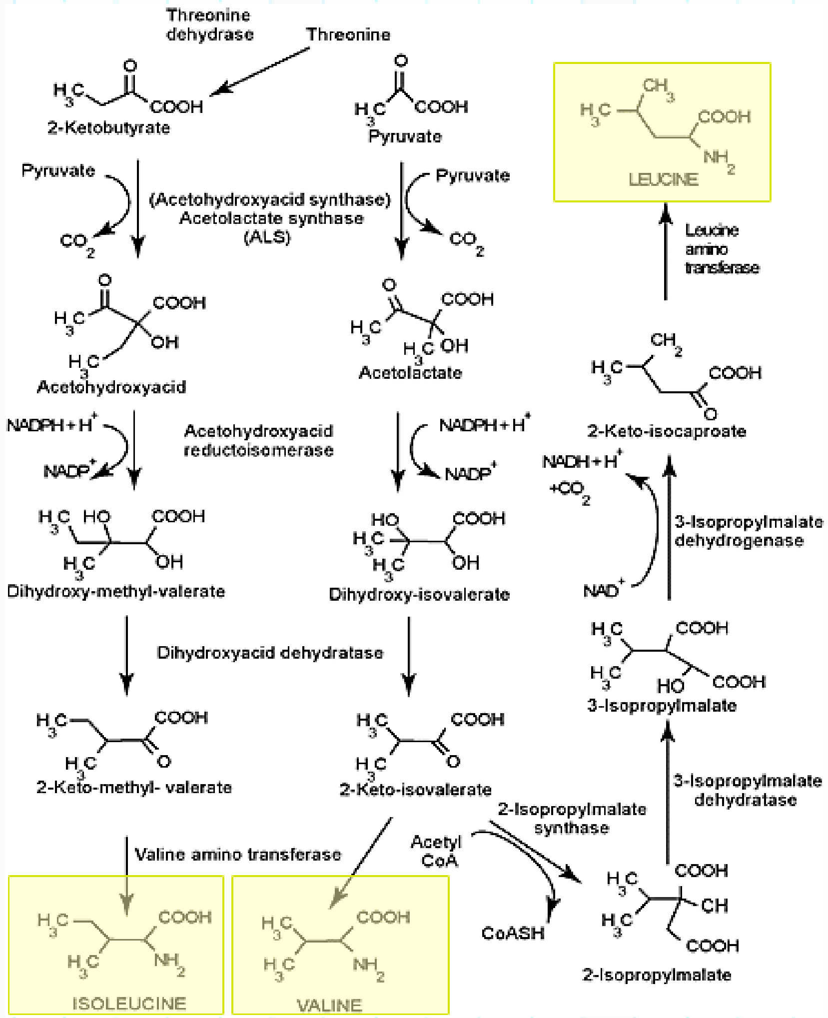
Herbicide Site of Action

Amino Acid - ALS Inhibitors (Group 2) – Branched Chain

ALS inhibitors effect the production of acetolactate that is crucial to the biosynthesis of the **valine**, **leucine**, and **isoleucine** branched chain amino acids. These amino acids are defined as the “building blocks” for plant growth and various proteins.

Several different chemistries make up the Amino Acid inhibitor group. The two primary groups are the ALS/AHAS (branched chain) and aromatic.

The most popular herbicides in the ALS group are the sulfonylureas.



Acetolactate synthase (ALS) pathway in the production of valine, isoleucine, and leucine.

Herbicide Site of Action

Amino Acid - ALS Inhibitors (Group 2) – Branched Chain

ALS herbicides are applied in very low rates due to the sensitivity that most plants have. Carryover can be an issue with these herbicides in soils depending on pH.

Due to the popularity of these herbicides in the late 20th century, resistance to this chemical family have been a known problem.

Weeds such as kochia, palmer amaranth, waterhemp, and shattercane used to have a very high susceptibility rate, but are now often resistant to ALS herbicides due to the continuous application over the years.

Kochia plant. Courtesy of Mark Hanson, CPS.

Palmer amaranth. Courtesy of Bob Hartzler, ISU.

Shattercane (*Sorghum bicolor*). Courtesy of University of Missouri - http://extension.missouri.edu/p/IPM1024-13

Herbicide Site of Action

Amino Acid - ALS Inhibitors (Group 2) – Branched Chain

Injury symptoms from ALS applications may take several days to be noticed. Affected plants will stop growing and may appear to be “dormant” until chlorosis begins.

Chlorosis on leaves may appear as striping, purpling or bronzing.

Lateral root pruning is a common symptom that eventually displays the “bottle brush effect.”

Crop injury can be highly variable depending on soil pH.

Corn plant exhibiting “purpling” from an ALS application. Photo courtesy of: https://edis.ifas.ufl.edu/LyraEDISServlet?command=getImageDetail&image_soid=FIGURE%202&document_soid=AG374&document_version=1

Stunted growth in a corn plantm following an ALS application. Photo courtesy of: https://www.btny.purdue.edu/Extension/Weeds/HerbInj2/Img/Large/001.JPG

Lateral root pruning or “bottle-brush” roots on corn due to ALS inhibitors. Photo courtesy of University of Missouri - http://extension.missouri.edu/explore/images/ipm1007amino17.jpg

Herbicide Site of Action

Pigment Inhibitors (Group 27)

Pigment Inhibitors are widely used in seed production as they have great control on weed species and low susceptibility for crop damage. These herbicides disrupt pigment production and alter chlorophyll processes.

Several of the trade names and chemical names are:

- Callisto® - Mesotrione
- Impact® - Topramezone
- Laudis® - Tembotrione
- Balance Flexx® - Isoxaflutole

Pigment Inhibitors can be applied preemergence and post emergence depending on the formulation and target species.

Herbicide Site of Action

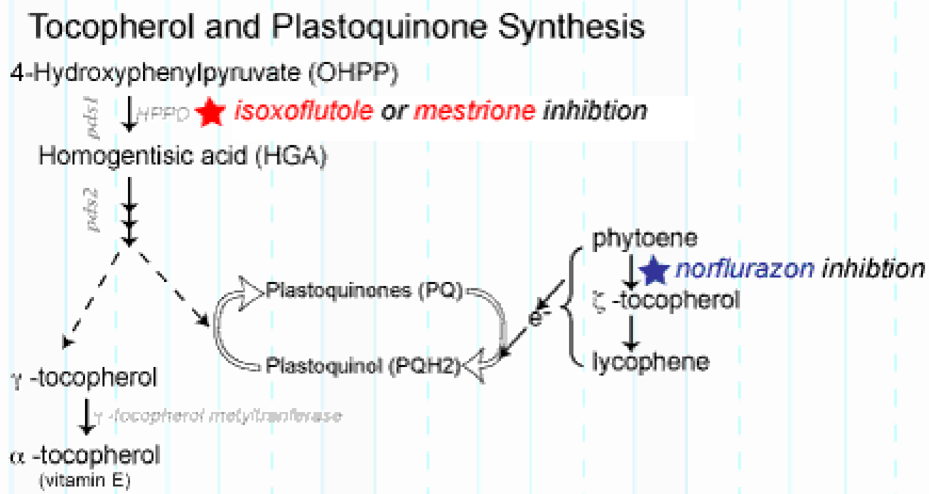
Pigment Inhibitors (Group 27)

Pigment inhibitor activity can easily be spotted due to the “bleaching affect” that is created when chlorophyll production is decreased. This bleaching effect is created when the synthesis of carotenoid pigments are blocked.

There are three different chemical families (isoxazole, pyrazolone, and triketone) that create the same plant symptoms, but do so at different sites of action.

Corn and other labeled crops are able to metabolize the enzymes that create the blockage.

Groundwater contamination should be a concern when applying Balance (Isoxazole) on soils that have a shallow water table



Tocopherol and plastoquinone biosynthesis in higher plants which are inhibited by isoxaflutole and mesotrione resulting in bleaching of the plants.

Herbicide Site of Action

Pigment Inhibitors (Group 27)

Injury symptoms to pigment inhibitors show up as white pigmentation in the leaves. Plant death will usually occur if more than 70% of the tissue turns white. It is common with some inbred lines to exhibit some bleaching regardless of the application rate.

Applicators should take note of wind direction when applying as drift to non–target species can be a possibility.

Injury from a Balance Flexx application in corn. Photo courtesy of: http://extension.missouri.edu/p/IPM1007-8

Bleaching effect from a Pigment Inhibitor application. Photo courtesy of: http://extension.missouri.edu/p/IPM1007-8

Herbicide Site of Action

Seedling Root Microtubule Inhibitors (Group 3)

Seedling root growth inhibitors is a mode of action that have proved to be very successful in controlling weeds in seed production fields. They are primarily used in preemergence applications.

Several of the trade names and chemical names are:

- Prowl® H20 - Pendimethalin
- Treflan® 4L - Trifluralin
- Sonalan® 10G - Ethalfluralin

Seedling root growth are primarily used in soybean production. They can be used in corn production applications, but special care should be taken with seed depth. Some formulations do require incorporation or moisture for activation.

Herbicide Site of Action

Seedling Root Microtubule Inhibitors (Group 3)

This group of herbicides affect the development and elongation of newly formed root cells. This is accomplished by the interference of mitosis and the altering of tubulin production. The new cells slowly continue to develop, but are not capable of nutrient uptake.

Root inhibitors are tightly held to soil particles, but can move within the soil profile depending on the formulation. With these characteristics, they typically remain active up to 60 days. Leaching is not a concern with root growth inhibitors. However, care should be taken as carryover can be problematic.

Movement within the targeted plants is minimal as root inhibitors do not experience translocation.

Corn roots can appear to be stunted and leaf margins can be purple in color from dinitroaniline injury. Courtesy of Iowa State University.

Herbicide Site of Action

Seedling Root Microtubule Inhibitors (Group 3)

Affected plants will display symptoms that are easy to identify. The newly developed roots will take on a "clubbed" effect and become swollen.

Above ground symptoms are comparable to nutrient deficiencies as the roots are no longer absorbing these vital components. Leaves will begin to yellow or even take on a bleached effect as the plant begins to shut down.

Soil characteristics should be noted as differences in soil organic material and texture will alter the effectiveness of the herbicide.

Incorporation of Treflan is required as UV light will cause it to rapidly decompose.

Seedlings displaying "clubbed roots" after a root inhibitor application. Photo courtesy of University of Missouri.
http://extension.missouri.edu/p/IPM1007-9

Corn seedlings experiencing poor root development after a root inhibitor application. Photo courtesy of University of Missouri.
http://extension.missouri.edu/p/IPM1007-9

Herbicide Site of Action

Seedling Shoot/Root Growth Inhibitors – Acetamides (Group 15)

Seedling Growth inhibitors play a vital role in controlling grasses and small-seeded broadleaves in seed production fields.

Several of the trade names and chemical names are:

- Warrant® - Acetochlor
- Degree® Xtra - Acetochlor
- Dual® II Magnum - Metolachlor
- Outlook® - Dimethenamid

Seedling shoot growth regulators are primarily used in preemergence applications, but can be used post-emergence depending on the formulation.

Shallow incorporation or moisture may be required for activation. Acetamides only prevent weeds from germinating and emerging. They do not effect plants that have already emerged.

Herbicide Site of Action

Seedling Shoot/Root Growth Inhibitors – Acetamides (Group 15)

Acetamides are absorbed differently by grasses and broadleaves. In grasses, absorption occurs in the newly emerging shoots. The site of absorption in broadleaves takes place at newly developed roots. The actual reaction process is not well defined, but it is thought that acetamides interfere with cell development in seedling plants through inhibition of long-chain fatty acids.

Herbicide coverage and placement is crucial to the effectiveness of acetamides as they do not actively translocate in the plant.

The low solubility of acetamides creates long residual coverage in most cropping systems. While carryover concern should be taken, it is not as prominent as microtubule inhibitors.

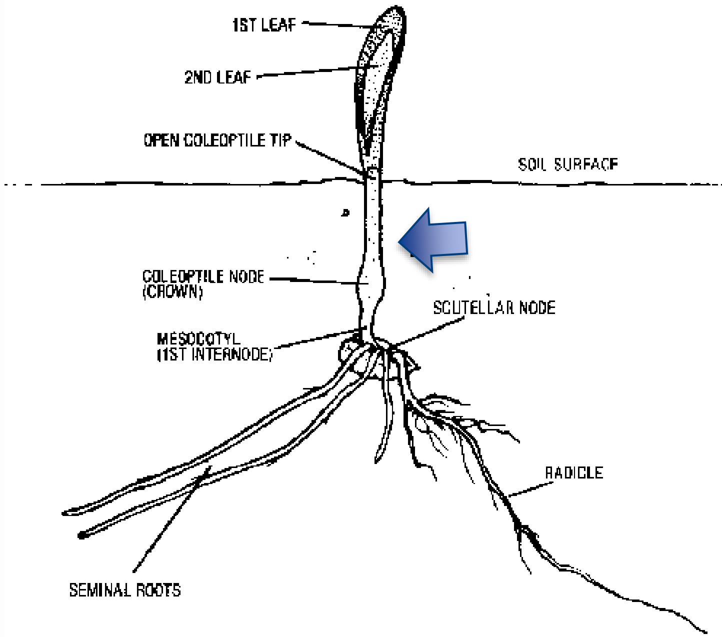


Figure 3. Emergence of the corn seedling.

Major uptake of Acetamide is at the coleoptile of weeds (arrow in picture).

Herbicide Site of Action

Seedling Shoot/Root Growth Inhibitors – Acetamides (Group 15)

Shoot failure is the most common symptom for grasses that have been exposed to acetamide herbicides. In severe cases, the plants will exhibit a "whipping" type appearance as the shoots fail to unravel from the whorl.

Injury symptoms on broadleaf plants are less dramatic as they typically only experience stunting.

Corn plants have the ability to metabolize acetamides, but susceptibility can be seen on some inbred lines.

Another valuable characteristic of the acetamides herbicides is that they can be used in some grain sorghum applications if the correct seed treatment is used.

Acetamide Injury to corn seedlings.
http://www.iasoybeans.com/sites/default/files/production-research/c715.pdf

Acetamide Injury to corn seedlings.

Herbicide Site of Action

Growth Regulators (Group 4)

Synthetic growth regulators were one of the first commercially available herbicides for crop production. It's persistence and versatility have allowed it to be a very successful tool when controlling broadleaf weeds. Dozens of formulations are available depending on the target application.

Several of the trade names and chemical names are:

- 2,4-D Amine 4® - 2,4-D
- Banvel® - Dicamba
- Clarity® - Dicamba
- Status® - Diflufenzopyr

Growth regulators can be used both for preemergence and post-emergence applications for broadleaf control. It is an ideal burndown component as it can be tank mixed with a variety of different modes of action.

2,4-D Amine 4

Banvel® Herbicide

STATUS® herbicide

Clarity® herbicide

Herbicide Site of Action

Growth Regulators (Group 4)

Growth regulators influence cell growth and differentiation. This mode of action is made up of two primary site actions: synthetic auxin and auxin transport inhibitors. These herbicides translocate through the plant and mimic natural growth hormones that effect cell development and protein production.

The affect on broadleaves is substantially higher because of the quick root absorption and movement within the plant. Grasses have lower movement within the plant and can slowly metabolize these herbicides.

Care should be taken if being used in post-emergence applications as corn plants can become brittle after being exposed to growth regulators. This brittleness at the joints can promote lodging during certain weather situations.

Growth regulators rapidly breakdown and do not pose any environmental concerns.

Corn brace root injury from growth regulator herbicides applied too late in the corn plant's development. Courtesy of Purdue University.

Herbicide Site of Action

Growth Regulators (Group 4)

Broadleaves that have been exposed to growth regulator herbicides experience symptoms in a very timely manner. Due to the increased level of hormones present in the plant, epinasty or "drooping" can be seen within one to two hours after the application.

Other growth symptoms, such as leaf cupping, reproduction abnormalities, and stunted plant growth may be present as well.

Safeners should be used when applying growth regulators to seed production fields.

Applicators should be aware that growth regulator herbicides have a very high potential to drift off target. The amine and salt formulations should be used if drift concerns are present.

Growth regulatory herbicide lodging in corn. Courtesy of the University of Wisconsin. http://fyi.uwex.edu/weedsci/1917-2/

Growth regulatory herbicide injury to corn. http://fyi.uwex.edu/weedsci/1917-2/

Growth regulatory herbicide "cupping" injury of soybean.

Herbicide Application

Application of herbicides in corn seed production fields can be challenging due to:

- Inbred sensitivity to the herbicide being used.
- Herbicide restrictions on the label to application method and timing.
- Poor relationship between inbred line and herbicide
- Lack of knowledge of herbicide formulation and inbred sensitivity
- Timing and weather challenges which affect herbicide uptake and metabolism by the plant

Fortunately, there are ways to overcome some of these challenges. Most important is the need to have good communication with company representatives in a timely manner.

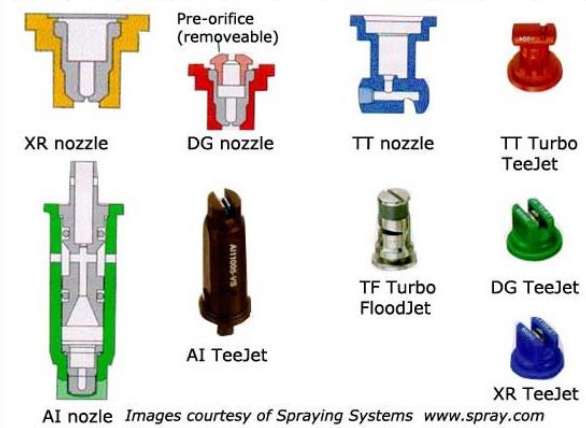
It is important to understand the formulation and chemical properties of the herbicide. Make sure to read and understand the product label. Questions to be asked are:

- Does this formulation utilize a safener?
- Is the formulation a control-release or an EC formulation which may result in more crop injury.
- What are the application methods per the label. Can drop-nozzles or spray hoods be used in making the application?
- Can the recommended rate be lowered with product tank mixing to reduce crop injury?

Herbicide Application

Adjusting the application method can help to minimize crop risk. The use of drop nozzles, hoods, reduced pressure, and different nozzles to reduce the "burn" potential.

The use of drop nozzles or drop extensions apply the herbicide closer to the ground where more of the chemical is applied to the weeds and less is taken up by the crop.
http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1030652583&topicorder=5&maxto=5



Selection of the correct spray nozzle can help in reducing drift and potential leaf burn.
http://www.stewardshipcommunity.com/best-spraying-practices/knapsack-spraying/nozzle-selection-and-their-optimised-use/nozzle-selection-slides-21-end.html

Hood sprayers are helpful in keeping the herbicide off of a sensitive crop.
http://farmprogress.com/story-going-under-hood-to-treat-pigweed-14-53490

Rotational Restrictions

Most herbicides used in corn seed production have guidelines related to crop rotation intervals. These intervals are vital when determining possible crop rotations. These intervals can be found on the supplied label.

There are several factors that determine the carryover of a herbicide from one season to the next. Dry and cold field conditions will slow down the degradation process while warm temperatures along with higher levels of moisture promote the degradation process. Tillage can also play a part in the breakdown of herbicides as no-till and reduced tillage keep herbicide concentrations near the surface. Conventional tillage practices promote the dilution of the herbicide within the soil profile.

The impact on seed production is elevated because many in – bred lines have increased susceptibility to multiple modes of action. In addition, in – bred seedlings can have enhanced levels of sensitivity during the early growth stages as they may not have the desired level of vigor early on.

Rotational Restrictions

Label Example

Below is an example of a crop rotation guideline

- Often times it is simply presented in a table versus text

ROTATIONAL CROP RESTRICTIONS

The interval between application and planting rotational crops is given below. Always exclude counting days when the ground is frozen. Planting at intervals less than specified below may result in crop injury. Moisture is essential for the degradations of this herbicide in soil. If dry weather prevails, use cultivation to allow herbicide contact with moist soil.

- Planting/replanting restrictions for DIFLEXX Herbicide applications of 24 fluid ounces per acre or less: Corn can be replanted immediately following an application of DIFLEXX herbicide (care should be taken that corn seed does not come into direct contact with the herbicide). The rotational interval is 60 days for barley, cotton, oat, sorghum, soybean and wheat and 120 days for all other crops.
- Planting/replanting restrictions for DIFLEXX Herbicide applications of more than 24 fluid ounces and up to 64 fluid ounces per acre: Corn, sorghum, cotton (east of Rocky Mountains) and all other crops grown in areas with 30" or more of annual rainfall may be planted 120 days or more after application. Barley, oat, wheat and other grass seedlings grown east of the Mississippi River may be planted 60, 90 and 120 days following DIFLEXX Herbicide application rates of 24-32, 33-48, and 49-64 fluid ounces/acre, respectively. Barley, oat, wheat and other grass seedlings grown west of the Mississippi River may be planted 60, 90, 135 and 180 days following DIFLEXX Herbicide application rates of 16, 17-32, 33-48, and 49-64 fluid ounces/acre, respectively. For all other crops in areas with less than 30" of annual rainfall, the interval between application and planting is 180 days or more.

Per Diflexx label - http://www.agrian.com/pdfs/DiFlexx_Label1.pdf

Summary

Knowing and understanding herbicide modes of action and characteristics will ultimately help seed corn producers make better decisions when determining what herbicides to use. Key points to remember when selecting a herbicide to use:

- Mode of action and herbicide characteristics
- In bred sensitivity
- Application timing and label guidelines
- Residual activity and carryover concerns

Communication with seed production company representatives is imperative as they may have additional guidelines and testing results.

The overall goal is to prevent weeds from emerging in seed production fields. If weeds do emerge, we need to eliminate them in an efficient manner that does not affect the overall production of seed corn.

It is important to become familiar with injury symptoms to understand the timing and effectiveness of the herbicide that was applied. Several modes of action have key injury characteristics that make them easier to identify.

Summary

Herbicides are just one tool that seed production growers can use to control weeds in their fields… Management practices, such as tillage, cover crop usage, and crop rotation, can be used in combination to make herbicides more effective long term.

An example of a weed free seed production field

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