SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter: 42
Herbicide Injury to Corn

Sharon A. Clay (Sharon.Clay@sdstate.edu)

Herbicides can cause predictable symptoms to plants. Injury symptoms may be due to improper application, unintentional crop exposure (e.g., drift or carryover from past applications), or may develop if adverse environmental conditions (e.g., cold, dry, hot) occur after application. The purpose of this section is to show injury symptoms and discuss the mode of action of commonly used herbicides that occur in South Dakota corn production. Photographs and information are provided to assist in identification of herbicide injury symptoms, although symptoms may be due to other causes such as disease, or abiotic stress such as drought, cold, or hail damage.

Introduction

Herbicide injury to corn can occur for many reasons including:

- Carryover from previous year's application.
- Carryover from early spring burn-down applications.
- Drift from nearby applications.
- Improper application of labeled chemicals (improper dose or growth stage).
- Applying the chemical when corn is under environmental stress.
- Tank or boom contamination with chemicals left over from previous applications.
- Double or incorrect overlap application.

Herbicide injury is often difficult to diagnose. At times, chemical carryover problems may not be seen until an application of a similar mode-of-action chemical is applied in the current season. In addition, the symptoms expressed in corn may not be due to herbicide injury. Environmental factors such as drought, high temperature, wind scouring, frost, or waterlogged conditions may be responsible. Root pruning from insects, purpling, yellowing, or dead tissue may occur due to nutrient deficiencies or toxicity levels, or mechanical damage could also result in injury that, at first, appears to be due to herbicides.

When diagnosing problems in the field, there are several things to observe. Look for patterns in the field associated with soil type, low or high spots, overspray in border rows, or overlap patterns from application equipment. Operator error (uncalibrated equipment, wrong chemical, or overlaps) may be the cause. But interactions with temperature, crop vigor, and soil type may combine to cause injury even if the chemical has been properly applied. If injury is not severe, most times corn will recover when growing conditions become favorable for growth.

Herbicides control plants in different ways. Herbicides that target the same specific biochemical or biophysical process in a plant to disrupt plant development are grouped into families. The Weed Science Society of America has designated a code for the primary site of action (WSSA Group #) that herbicide manufacturers often list on an herbicide label. This designation: 1) helps the user understand the way that the herbicide works and 2) should be consulted to help rotate sites of action in order to minimize the outbreak of herbicide-resistant weeds.

The herbicides in each of the families listed below are just examples of herbicide chemistries. Many herbicides have the same chemical but are listed by various trade names because of marketing. Premix herbicides may contain two or more of the families listed. Premix combinations or the addition of spray adjuvants or additives may result in heightened plant injury if applied during periods of stress, or at incorrect timings or rates. As with any herbicide application, always read and follow label instructions. Unfortunately, problems can occur, and the information provided may be used as a first reference. If crop injury is more than cosmetic, more detailed information will be needed to confirm the true cause of the problem.

Acetyl-CoA Carboxylase (ACCase) Inhibitors (WSSA Group 1)

WSSA Group 1 herbicides block the ACCase enzyme that is the first step in fatty acid synthesis. There are two major herbicide chemistries in this group, aryloxphenoypropionate and cyclohexanediones type. These herbicides are not labeled on corn and are often used to control volunteer corn in broadleaf crops such as soybean.

Examples: quizalofop (Assure; Targa); sethoxydim (Poast; Rezult G; Segment)

Site and Mechanism of Action: Stops Acetyl-CoA carboxylase (ACCase) enzyme in the plant and inhibits the formation of lipids used for the formation of cell and intercellular membranes.

Appearance of Symptoms: Corn is sensitive to these grass herbicides (Figures 42.1 and 42.2). Symptoms may first appear 2 to 4 days after treatment with wilting plants. If applied to corn before emergence, corn may not emerge. Severe symptoms take 1 to 3 weeks to develop after treatment. Leaf chlorosis (yellowing) begins followed by death of young leaves, with older leaves looking untouched. To determine whether this injury has occurred, pull the whorl from the corn plant and the base will be brown and mushy.

Injury Symptoms	Typical Causes of Injury
• Yellowing or reddening of new leaves	• Misapplication
• Stunting of plant	• Tank contamination
• Death of tissue and browning	• Drift from adjacent fields
• Growing point dies, becomes brown and mushy	

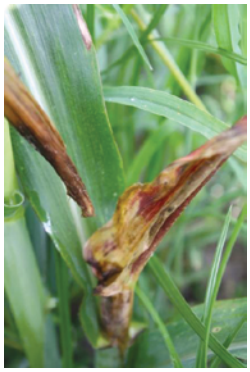

Figure 42.1 ACCase inhibitor symptoms, yellowing and bleaching (right), necrotic leaves (left). (Pictures courtesy of University of Wisconsin Extension and Sarah Berger, Univ. Florida, IFAS Extension)

Figure 42.2 Puma (fenoxaprop) applied at 10% tank contamination. (Mike Cowbrough Ontario Ministry of Agriculture, Food and Rural Affairs)

Acetolactate Synthase (ALS) Inhibitor (WSSA Group 2)

There are five chemical subgroups of ALS inhibitor chemistries: sulfonylureas (SU); imidazolinone (IMI); pyrimidinylthiobenzoates; triazolopyrimidines; and sulfonyaminocarbonyl-triazolinones. These compounds are found alone or in many premix combinations and, depending on the chemical, will control grasses, broadleaf weeds, or both. There are many of these herbicides registered for use in corn. However, the application of the wrong chemical can result in injury.

Sulfonylureas: There are many herbicides in this family and many premix herbicide combinations that contain this herbicide family. Examples of a few of the herbicides registered for corn include: thifensulfuron (Harmony 50SG; Thief; Treaty; Volta); halosulfuron (Permit, Sandea, Herbivore); indosulfuron methyl-sodium (Autumn); nicosulfuron (Accent, Adapt, Primero, NIC-IT 2L); and rimsulfuron (Resolve Pruvin, Rule, Solida).

Imidazolinone: Herbicides of this subgroup include imazaquin (Scepter); imazethapyr (Pursuit); and imazamox (Beyond, Clearmax). These herbicides are typically used in broadleaf crops, however, imazethapyr is labeled for use on CLEARFIELD corn varieties.

Pyrimidinylthiobenzoates: An example of an herbicide in this subgroup is pyrithiobac-sodium (Pyrimax; Staple), which is used for broadleaf weeds and some grasses in cotton.

Triazolopyrimidines: An example of an herbicide in this subgroup is flumetsulam (Python), which is labeled for soil and postemergent application in corn and soybean to control a wide array of broadleaf weeds.

Figure 42.3 Corn in the foreground shorter than plants in the background indicating stunted plants and stunted internode elongation, early signs of injury caused by ALS herbicides. (Pictures courtesy of University of Wisconsin Extension)

Figure 42.4 Bottle-brush roots due to ALS herbicides. (Pictures courtesy of University of Wisconsin Extension)

Figure 42.5 Shortened internodes due to post-ALS herbicide application. (Pictures courtesy of University of Wisconsin Extension)

Figure 42.6 ALS herbicide applied at V8. Note the pinched cobs on each corn ear. (Pictures courtesy of University of Wisconsin Extension)

Sulfonyaminocarbonyl-triazolinones: Examples of herbicides in this subgroup include flucarbonzone (Everest, PrePare, Sierra) and propoxycarbozone (Olympus). Both of these chemistries are used to control grass weeds in wheat.

Site and Mechanism of Action: These herbicides block the acetolactate synthase enzyme and stop the formation of branched chain amino acids.

Appearance of Symptoms: Two to 4 days after treatment the growing point becomes yellow and plant death is seen within 7 to 10 days after treatment (Figures 42.3, 42.4, and 42.5). Plants may have red or purple leaf veins. Shortened internodes may be observed. Yellow "flash" with chlorosis and yellowing in the whorl and crinkled leaf edge may be observed. Corn ears may have pinched appearance (Figure 42.6).

Injury Symptoms	Typical Causes of Injury
• Stunted plants, stunted internodes (Figs. 42.3, 42.5) • Yellow translucent leaves • Death of growing point • Bottle-brush roots (Fig. 42.4) • Corn ears may have pinched appearance (Fig. 42.6)	• Hybrid sensitivity • Applied too late • Carryover from previous application

Inhibitors of Microtubule Assembly (WSSA Group 3)

These herbicides bind to tubulin and inhibit polymerization of microtubules in the cell, which leads to loss of structure and function. This stops the spindle apparatus during cell division and chromosomes cannot separate and form new cells. Swelling of root tips is often observed as well as shoot malformation. There are four main chemistry groups in the grouping, benzamides, dinitroanilines, phosphoamidates, and pyridines.

Examples: Pendimethalin (Prowl, Pendant); trifluralin (Treflan Products)

Site and Mechanism of Action: These herbicides bind to tubulin and inhibit polymerization of microtubules in the cell, which leads to loss of structure and function of the microtubule. This stops the spindle apparatus from forming during cell division and chromosomes cannot separate and form new cells.

Figure 42.7. Prowl injury to corn root clubbing (left) compared with uninjured corn (right) (Photo courtesy of Sarah Berger, Univ. Florida IFAS Extension).

Appearance of Symptoms: Short, thickened roots (Figure 42.7). Swelling of root tips is often observed as well as shoot malformation. Shoot may leaf out below ground or if above ground, shoot may show purpling.

Injury Symptoms	Typical Causes of Injury
• Roots stunted • Root clubbing (Fig. 42.7) • Shoots may be purple	• Applied at the wrong time • Shallow planting of crop with exposure to herbicide during germination

Auxin Mimic Herbicides (WSSA Group 4)

There are many subfamilies of chemistries that act as synthetic auxin. The families include benzoic acid, phenoxycarboxylic acids, pyridine carboxylic acids, and quinolone carboxylic acids. There are many herbicides in this group and many premix herbicide combinations that contain these herbicide families.

Examples: Auxin mimic herbicides include: 2,4-D; dicamba (Banvel, Clarity, Distinct, Status, Diablo, Rifle); clopyralid (Stinger, Solix, Clean Slate), fluroxypyr (Starane Ultra, Comet). Premix combinations such as clopyralid + fluroxypyr (Widematch, Colt AD, Truslate) may contain one or more of these herbicide types.

Site and Mechanism of Action: The specific site of binding for these herbicides has not been identified. These herbicides all act similar to auxin, a growth regulator naturally produced inside the plant. The addition of synthetic auxin disrupts nucleic acid metabolism and protein synthesis, which ultimately leads to plant death. These herbicides often accelerate shoot growth and inhibit root growth.

Phenoxycarboxylic Acid Subgroup

Example: 2,4-D

Appearance of Symptoms: Symptoms appear within hours of application on sensitive species. Corn symptoms may first be observed as wilt. Later, leaves may be tightly rolled in the whorl (onion-leaf) (Figure 42.8), stalk may be brittle, and brace roots may proliferate (Figure 42.10). Some corn hybrids are more sensitive than others. The amine formulation of 2,4-D is less volatile and less likely to drift compared with ester formulations, especially at warmer temperatures (> 70°F). If corn is growing quickly, symptoms may be more severe. High winds may cause treated plants to undergo green snap of corn stems or lodging due to root injury. If the herbicide is applied too late in the season, grain fill may be poor (Figure 42.9).

Figure 42.8 Onion leaf and shortened roots due to 2,4-D application. (Picture courtesy of University of Wisconsin Extension)

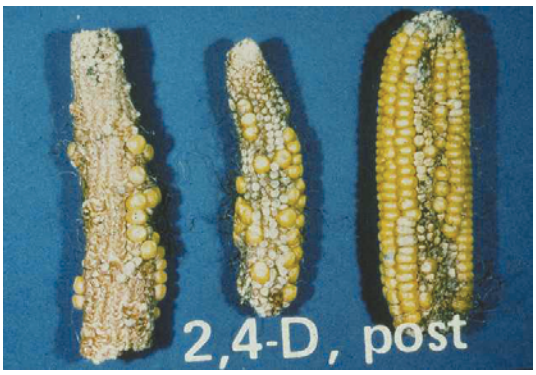

Figure 42.9 Reduced grain fill due to too late an application of 2,4-D. (Picture courtesy of OFMRA, Ontario, Canada)

Figure 42.10 Dicamba brace root and root injury. (Pictures courtesy of (left) Sarah Berger, Univ. Florida IFAS Extension and (right) University of Wisconsin Extension)

Injury Symptoms

- Rolled leaves
- Fused brace roots
- Stalk bending and brittleness
- Missing kernels on ear (Fig. 42.9)

Typical Causes of Injury

- Applied to rapidly growing corn
- Applied too late

Benzoic Acid Subgroup

Examples: dicamba (Banvel, Clarity, Distinct, Status, Diablo, Rifle)

Appearance of Symptoms: First appearance of symptoms can be within hours after application on sensitive species. Injury may occur if used as a pre-emergence application and corn is planted shallow, planted in an open seed furrow, or if the soil is coarse and sandy. If applied early post-emergence, onion leafing or brace root abnormalities may be noted if heavy rains occur soon after application. Corn plants may lodge or have green snap in windstorms. Grain fill may be compromised, if applied too late in the season.

Figure 42.11 Atrazine injury to corn from pre-emergence application when corn was growing under cooler than normal conditions. (Photo courtesy of Purdue Extension)

Inhibitors of Photosynthesis (WSSA Groups 5, 6, and 7)

These groups contain many diverse herbicide families, and the classification by group is done by how each family interacts specifically with the Photosystem II binding sites. If the herbicide binds at Photosystem II site A, then the herbicide is placed in Group 5; if binding occurs at Photosystem II site B, then the herbicide is considered in Group 6; and if at Photosystem II site A but has a different binding mechanism than herbicides in Group 5, then the herbicides are placed in Group 7. While the site of action differs for these different groups, the herbicide symptoms are similar.

Figure 42.12 Buctril (bromoxynil) injury to corn. Note that the leaves that were present are most injured, newest leaves coming out of the whorl have little or no injury. (Photo courtesy of University of Wisconsin Extension)

WSSA Group 5: Atrazine (Aatrex) and metribuzin (Glory. Dimetric) (can be applied pre- emergence or postemergence to corn).

WSSA Group 6: Bromoxynil (Bronate, Buctril) and bentazon (Basagran) (applied postemergence to corn)

WSSA Group 7: Amides and Ureas

Site and Mechanism of Action: All inhibit photosynthesis but bind or interact at different sites in Photosystem II. When photosynthesis stops, electron flow, CO_2 fixation, ATP and $NADPH_2$ formation are all inhibited. In addition, the electrons are now free to form free radicles with other compounds and result in cell membrane disruption.

Figure 42.13 Basagran (bentazon) injury to corn. Basagran is not translocated in the plant so injury is seen where droplets hit the leaf. The premix herbicide Laddok (bentazon plus atrazine) may also result in this type of injury. (Picture courtesy of Erick Larson at the Mississippi State University Extension Service; MSUCares, Mississippi State University)

Appearance of Symptoms: Typically first symptoms are seen a few days after application (Figures 42.11, 42.12, 42.13). Water-soaked appearance of leaves, yellowing, and browning (necrosis) (of oldest leaves if applied to soil, spotting on leaves if postapplied).

Injury Symptoms	Typical Causes of Injury
• Yellow leaves • Necrotic spotting • Older leaves most affected	• Cool, wet conditions slowing corn growth • Crop oil synergy if applied postemergence

Inhibitors of Lipid Synthesis (not ACCase inhibition) (WSSA Group 8)

The herbicides in this category inhibit plant processes that include fatty acid and lipid biosynthesis but have a different site of action than those of WSSA Group 1. There is poor epicuticular wax formation on leaves, which leads to greater abiotic (water stress) and/or biotic stresses (e.g., inability to withstand pathogens or insect attack) for the plant. Thiocarbamate and phosphorodithioates (not used in corn) are two herbicide chemistries in this grouping.

Examples of Thiocarbamate Herbicides: EPTC + safener (Eradicane); butylate + safener (Sutan +)

Site and Mechanism of Action: The specific site of action for these herbicides has not been identified. The mechanism of action is to inhibit the growth of roots or shoots of seedlings. These herbicides stop fatty acid biosynthesis and other lipids, reducing the epicuticular wax formation on leaves.

Appearance of Symptoms: Symptoms appear during or soon after plant emergence (Figure 42.14). Plant may leaf out underground or if the plant emerges, will be stunted and have malformed leaves, and reduced or stunted root growth.

Figure 42.14 EPTC or butylate injury to corn seedling. This may occur if herbicide without safener is applied or if emergence is delayed due to cool, wet soils. (Picture courtesy of Purdue University Extension)

Figure 42.15 Glyphosate drift to nonglyphosate-resistant corn. (Photo University of Wisconsin Extension)

Amino Acid Derivative Herbicide (WSSA Group 9)

The active ingredient glyphosate is the common name for all trade-name herbicides in this family. Glyphosate is also found in premix herbicide combinations. Only corn hybrids with the glyphosate-resistant trait should be treated by postemergence applications of glyphosate, although this herbicide can be applied in burn-down treatments before corn emergence.

Example: glyphosate (Roundup and many others with active ingredient of glyphosate)

Site and Mechanism of Action: This herbicide binds to the 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS) enzyme, which stops synthesis of aromatic amino acids (amino acids that contain a phenyl ring).

Figure 42.16 Glyphosate drift injury to nonglyphosate-resistant corn. (Photo Missouri Extension)

The depletion of these aromatic amino acids leads to problems in protein synthesis and other growth pathways.

Appearance of Symptoms: Symptoms are slow to develop. Wilted plants may be seen in as little as 3 to as long as 10 days after exposure (Figures 42.15, 42.16, 42.17). Symptoms become more severe with time after treatment. Extreme heat, cold, or drought will slow and reduce the effects of glyphosate.

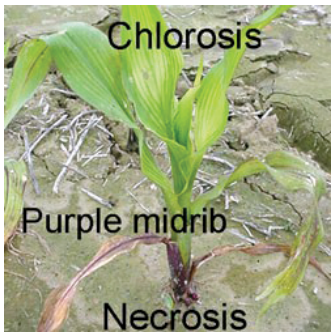

Figure 42.17 Purple midrib due to glyphosate injury. (Picture courtesy of Erick Larson at the Mississippi State University Extension Service; MSUCares, Mississippi State University, diagnosing glyphosate injury at: http://msucares.com/crops/corn19.html). Note that purpling may also be caused by hybrid type OR phosphorus deficiency. If a nutrient deficiency was the problem, however, the entire plant would be compromised when small, not just a few leaves.

Injury Symptoms

- Yellow, then brown foliage
- Growing point dies
- Purpling of midveins may be present on older leaves

Typical Causes of Injury

- Misapplied to nonglyphosate-resistant corn

Phosphoric Acid Type Herbicide (WSSA Group 10)

The active ingredient glufosinate is the common name for all trade-name herbicides in this family. Only corn hybrids with glufosinate-resistant trait (LibertyLink®) should be treated by postemergence applications of glufosinate, although this herbicide can be applied in burn-down treatments before corn emergence.

Example: glufosinate (Liberty 280, Rely, Ignite, Finale)

Site and Mechanism of Action: This herbicide stops the activity of glutamine synthase an enzyme needed

Figure 42.18 Glufosinate injury to non-LibertyLink® corn. (Photo courtesy of Missouri Extension)

Figure 42.19 Glufosinate (Liberty) damage to non-LibertyLink® corn. (Photo courtesy of University of Wisconsin Extension)

to convert ammonia into other nitrogen compounds. Consequently, ammonia accumulates to toxic levels in leaves causing cell destruction and inhibiting photosynthesis. In addition, glutamine, a needed amino acid in plant growth, is depleted.

Appearance of Symptoms: Only apply this herbicide to GMO corn hybrids that have the LibertyLink trait. Symptoms on LibertyLink® corn may appear if applied when corn is stressed (drought, too hot, or excessively wet conditions) or if applied too late in the season. Drift on non-LibertyLink® hybrids will result in symptoms 3 to 5 days after treatment (Figures 42.18 and 42.19).

Injury Symptoms	Typical Causes of Injury
• Pale, yellow, or purple leaves	• Applied too late in the season
• Water-soaked lesions	• Misapplied to non-LibertyLink® corn

Pigment Inhibitors (WSSA Groups 13 and 27)

These two groups of herbicides block the formation of pigments, the compounds that provide color to the plant leaves, through two different mechanisms. Plants affected by herbicides in either of these groups have bleached white leaves because chlorophyll and other pigment compounds are not formed. Clomazone (Command) is a WSSA Group 13 herbicide that inhibits the 1-deoxy-D-xylose 5-phostage synthatase (DOXP synthase), which stops plastid isoprenoid synthesis. Herbicides in Group 27 inhibit the 4-hydroxyhenyl-pyruvatedioxygenasis (4-HPPD) enzyme, which stops plastoquinone biosynthesis, inhibiting caretonoid and chlorophyll synthesis.

DOXP Inhibitor Subgroup

Example: Group 13 herbicide clomazone (Command, Epic)

Site and Mechanism of Action: This herbicide inhibits the 1-deoxy-D-xylose 5-phostage synthatase (DOXP synthase) enzyme found in the carotenoid and chlorophyll pigment pathway in plants (Figure 42.20). The lack of compounds in the leaf that give the leaf color is the reason why the plant appears bleached white.

Appearance of Symptoms: Plant leaves are white.

Injury Symptoms	Typical Causes of Injury
• White tissue	• Application on cool, wet, or sandy soils
• Poor emergence	• Ca
• Stunted plants	

Figure 42.20 Injury of isoxaflutole + atrazine WITHOUT crop safener. This type of injury will be similar for both the DOXP and HPPD inhibitors. (Mike Cowbrough, Ontario Ministry of Agriculture, Food and Rural Affairs)

HPPD Inhibitor Subgroup

Example: Group 27 herbicides include isoxaflutole (Balance); mesotrione (Callisto); tembotrione (Laudis); topramezone (Impact)

Site and Mechanism of Action: These herbicides bind at 4-hydroxyhenyl-pyruvate dioxygenase (4-HPPD), which stops caretonoid biosynthesis and results in bleached (white) plants

Appearance of Symptoms: Appearance of bleached (white) tissue on leaves within a few days after exposure.

Note: Some herbicides are now formulated with safeners to protect the crop plant from injury. For example, Balance Flexx 2SC* (Bayer) contains isoxaflutole plus a safener (cyprosulfamide). Safeners can protect the plant by increasing the herbicide metabolism (breakdown of herbicide) in the plant but not the weed.

Protoporphyrinogen Oxidase Inhibitors (WSSA Group 14)

The WSSA Group 14 herbicides inhibit protoporphyrinogen oxidase (Protox or PPO inhibitor). This stops chlorophyll and heme biosynthesis, which results a series of events that lead to singlet oxygen and radical formation. The free radicals then begin a chain reaction of lipid perioxidation. WSSA Group 14 contains many different types of herbicide chemistries including diphenylethers, oxadiazoles, phenpyrazoles, and pyrimidindiones.

Examples: fomesafen (Flexstar, Reflex, Prefix); carfentrazone (Aim); flumioxazin (Valor, Outflank, Panther); saflufenacil (Sharpen, Kixor)

Site and Mechanism of Action: Herbicides in this group inhibit the protoporphyrinogen oxidase (PROTOX) enzyme resulting in cell membrane destruction.

Appearance of Symptoms: Appearance of necrotic (dead tissue) speckling on leaves within a few days after exposure (Figures 42.21-42.23).

Injury Symptoms

- Water-soaked appearance
- White veins
- Brown tissue in areas that were water-soaked

Typical Causes of Injury

- Applying under high temperature and humidity increases the potential for crop injury

Figure 42.21 Symptoms of HPPD injury. Corn plants have chlorotic (yellow) to white veins (tiger stripping) and the lower leaves may droop. (Picture courtesy of University of Wisconsin Extension (left) and Illinois Extension (right).)

Figure 42.22 Corn with fomesafen injury. (Mike Cowbrough, Ontario Ministry of Agriculture, Food and Rural Affairs)

Figure 42.23 Saflufenacil injury to corn. The herbicide was applied postemergence to corn when it is labeled only for pre-emergence. Note that the symptoms look like symptoms shown for WSSA Group 15 (inhibitors of very long-chain fatty acid synthesis). (Mike Cowbrough, Ontario Ministry of Agriculture, Food and Rural Affairs)

Inhibitors of Synthesis of Very Long-Chain Fatty Acids (WSSA Group 15)

Acetamide, chloroacetamide, and oxyacetamide herbicides inhibit very long-chain fatty acid synthesis. This inhibition, in turn, reduces the formation of cell membranes which then inhibits plant growth.

Examples: metolachlor (Dual products); pryroxasulfone (Zidua); alachlor (Micro-Tech); acetochlor (Harness, Surpass, Volley, Breakfree and others); dimethenamid-p (Outlook, Propel, Establish and others)

Site and Mechanism of Action: These herbicides inhibit the formation of very long-chain fatty acids. The exact site of attachment is unknown. Plants do not emerge or growth of seedling roots or shoots is poor.

Figure 42.24 S-metolachlor (Dual) injury to corn. (Picture courtesy of Missouri Extension)

Appearance of Symptoms: If plants emerge, shoots often have buggy-whipped appearance (leaf entrapment) (Figure 42.24). These symptoms will be observed during or soon after plant emergence.

Injury Symptoms

- Poor emergence
- Stunted plants
- Leaf out before emergence
- Buggy whipping (leaf entrapment)

Typical Causes of Injury

- Overapplication
- Delayed corn emergence due to cold or waterlogged soil
- Hybrid sensitivity
- Applied during corn emergence (spike) which is too late
- Application to sandy soils

Auxin Transport Inhibitor (WSSA Group 19)

Example: Diflufenzopyr is in this group and is found only in herbicides premixed with other herbicides. Premix combinations include + Dicamba, Group 4; Distinct has 50% dicamba + 20% difluenzopyr; Status has 44% dicamba + 17% diflufenzopyr + safener; Celebrity Plus has nicosulfuron (Group 2) + dicamba + diflufenzopyr.

Site and Mechanism of Action: The exact site is unknown. This auxin transport inhibitor blocks natural auxin transport to roots and stems; there is a safener in Status that reduces the potential for corn injury.

Appearance of Symptoms: Symptoms on susceptible plants are often observed within hours.

Cell Membrane Disruptor, Photosystem I Electron Diverters (WSSA Group 22)

This herbicide group includes paraquat and diquat. These postemergence herbicides will injure all crops. The herbicide accepts electrons from Photosystem I and becomes a radical, which then reduces molecular oxygen to superoxide radicals and form hydrogen peroxide that continue to break down components of the cell.

Example: paraquat (Gramoxone Max; Gramoxone Inteon; Firestorm; Para-shot, Parazone 3L)

Site and Mechanism of Action: The site of action is in Photosystem I. These herbicides accept electrons from the photosystem, causing free radicals to be formed, followed by production of hydrogen peroxide that leads to destruction of cell membranes and other components of the cell.

Appearance of Symptoms: The free radicals destroy the integrity of cell membranes, which rapidly leads to leaf wilting and desiccation. Localized symptoms are often observed within hours of application (Figures 42.25 and 42.26). The first symptom is water-soaked lesions in spots on the plant. Because the herbicide is

contact type, the spots will form only where the herbicide was applied. Young leaves that had not emerged from the whorl will not show injury. Plants may outgrow the symptoms and may not suffer yield loss.

Injury Symptoms

- Water-soaked lesions
- Yellow spotting
- Dead tissues but only as spots

Typical Causes of Injury

- Drift
- Tank contamination
- Sprayed after corn emergence

Figure 42.25 Paraquat injury. (Photo courtesy of William M. Brown Jr., Bugwood.org)

Figure 42.26 Paraquat injury to older plants. Note absence of injury to young leaves in the whorl. (Photo courtesy of Purdue University Extension)

Summary

Avoid common causes of herbicide injury.

- Make sure that there is no residual herbicide left in the tank from another application, and clean the tank using label instructions to avoid contamination.
- Avoid overspray (areas of overlap of the sprayer) and drift. Overspray may cause residual herbicide carryover for future crops.
- Establish buffer zones with a safe distance to open water and wells.
- Be conscious of wind speed and direction to avoid drift to sensitive crops and noncrop areas.
- Before application, make sure the sprayer is calibrated. This should also involve checking all nozzles to make sure that the amount discharged and spray pattern is correct (See Chapter 41).
- Read all label instructions prior to herbicide mixing and make sure the crop is at the correct stage of growth for treatment.
- Recheck your calculations about how much herbicide and other adjuvants need to be added to the tank. Add the herbicide and adjuvants in the same order listed on the label to avoid mixing problems. If unsure about the compatibility of products, do the quart jar test (see herbicide labels) prior to adding large amounts to the tank.

If you suspect herbicide injury:

- Document crop injury symptoms (types), field patterns (the entire field, edges, only in specific areas), and timing of what symptoms were seen, when symptoms were seen, and the progression of symptoms.
- Check weather information to determine whether the injury may be due to frost, hail, sheer winds, or other weather-related problems.
- Contact the applicator or chemical representative.
- Photograph and document injury symptoms.
- Check growing points to determine whether plant can recover.
- Determine the extent of the injury.
- Map areas of the field that are damaged.
- Keep records of crop yields from undamaged and damaged areas.

References and Additional Information

Weed Science Society of America: http://wssa.net/ (accessed 5 November 2015).

The glyphosate, weeds, and crops website: http://www.glyphosateweedscrops.org/ (accessed 5 November 2015).

Acknowledgements

Support for this document was provided by South Dakota State University, SDSU Extension, South Dakota Agricultural Experiment Station and the South Dakota Corn Utilization Council.

Clay. S. 2016. Chapter 42: Herbicide Injury to Corn. In Clay, D.E., C.G. Carlson, S.A. Clay, and E. Byamukama (eds). iGrow Corn: Best Management Practices. South Dakota State University.

The preceding is presented for informational purposes only. SDSU does not endorse the services, methods or products described herein, and makes no representations or warranties of any kind regarding them.