Department of Crop Sciences
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How Herbicides Work

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A Short Course On How Herbicides Kill Weeds and Injure Crops

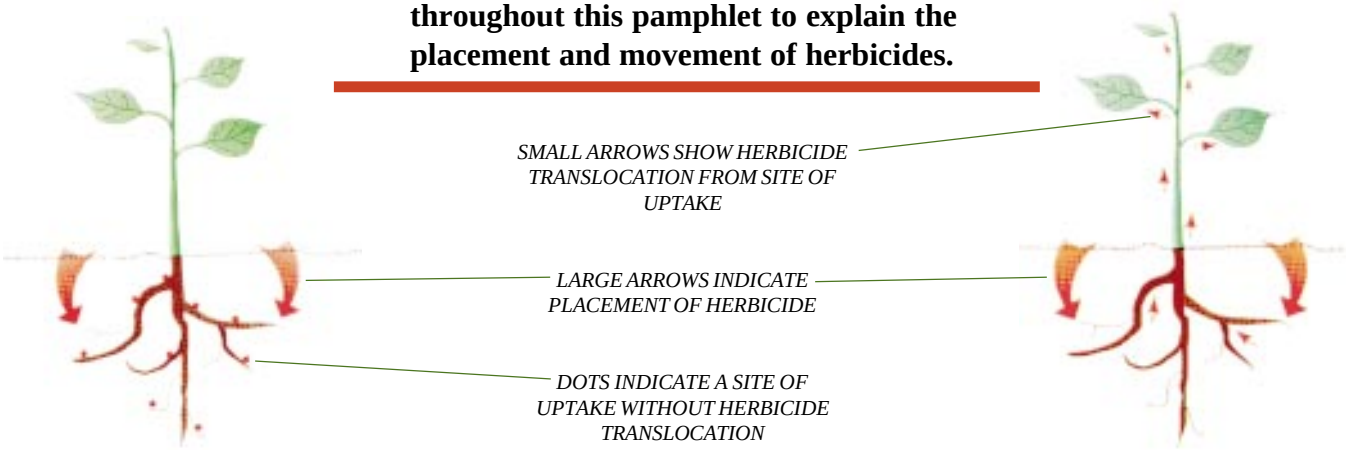
Welcome to the world of enzyme inhibitors and membrane disrupters, chemical tyrants that prevent plant photosynthesis, stop roots from growing, and in general make life miserable for weeds in your fields.

Herbicide knowledge is a precious commodity when you farm in the environmental age. It's no longer enough to simply apply herbicides on fields; you need to know how they work and learn the lingo. Besides, farmers armed with this knowledge can better assess the causes of crop injury when they occur.

This publication provides detailed explanations and illustrations on how various herbicides kill or prevent weeds from growing. Pictures of crop injury are included as a means of showing the effects of herbicidal activity on plants in general. The inclusion of trade names does not constitute an endorsement of any product or manufacturer.

We urge you to take this guide with you to the field when evaluating herbicide performance and looking for signs of crop injury. If you need additional help, your local extension adviser or chemical company representative may be able to answer further questions.

The following diagrams will be used throughout this pamphlet to explain the placement and movement of herbicides.



Soil Applied Herbicides

Root mitotic inhibitors

How they work: Block cell division.
Examples: *trifluralin (Treflan, others), pendimethalin (Prowl, Pentagon), ethalfluralin (Sonalan)*
Symptoms of injury:

- Root development is inhibited (root pruning) which leads to plant stunting.
- Stems and leaves turn purple due to phosphorus deficiency.
- A high concentration of herbicide near the soil surface may induce the formation of callus tissue on soybean stems, leading to stem breakage or lodging late in the growing season.

Pruned roots

Comments:

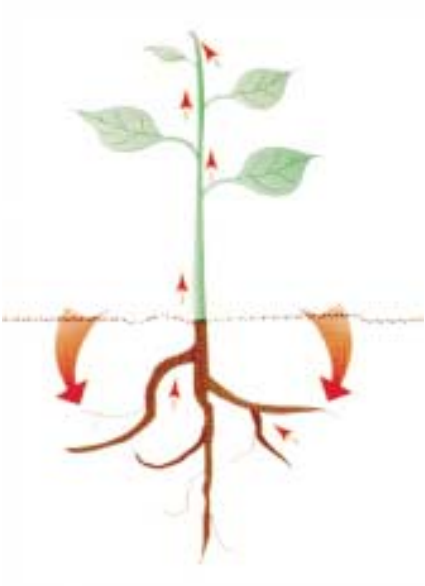
Dissipation of these herbicides is enhanced by anaerobic conditions in the soil. Carryover of pendimethalin and ethalfluralin is rare, while trifluralin carryover is more likely to injure corn, especially early planted hybrids which are slow to emerge. Injury from drift is uncommon. A surface application of pendimethalin may induce callus formation on soybean stems. Due to volatility and low water solubility, these herbicides (except pendimethalin) are usually incorporated into the soil.

Swollen Hypocotyl

Purple Corn

Pigment inhibitors

White Corn / Clomazone

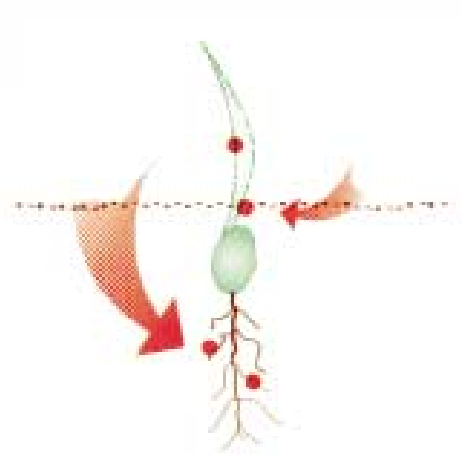


How they work: Contribute to chlorophyll destruction.
Examples: *clomazone (Command), norflurazon (Zorial)*
Symptoms of injury:
- Affected plant tissue is white or very light green in color; new and older leaves may be affected.

Comments:

Carryover to susceptible crops is possible where spray overlap or misapplication has occurred. Volatility injury is also possible if the herbicide is not immediately incorporated into the soil after application.

Shoot inhibitors



How they work: Affect cell growth and division. Specific sites of action unknown.
Examples: *alachlor (Lasso, Micro-Tech), metolachlor (Dual II), acetochlor (Surpass, TopNotch, Harness), dimethenamid (Frontier), EPTC (Eradicane), butylate (Sutan +), EPTC + acetochlor (DoublePlay)*
Symptoms of injury:
- Stunted plant shoots and leaf crinkling.
- Seedlings may leaf out underground, making emergence difficult.
- Grass seedling leaves may not unfurl correctly.

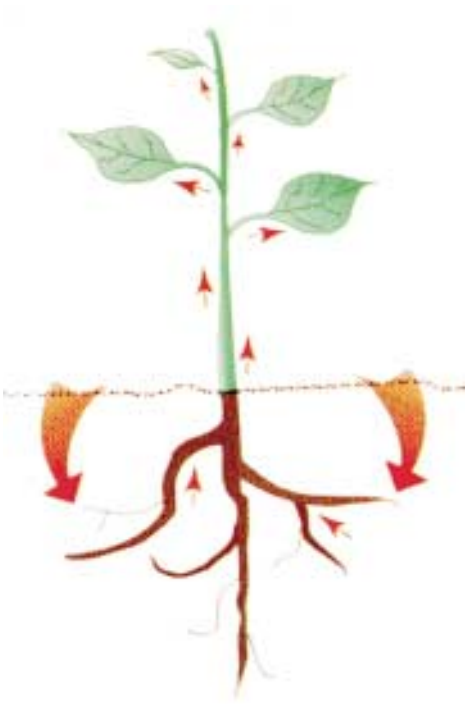
Comments:

Carryover injury is not likely, nor is injury from tank contamination. Direct injury to the crop can occur when the crop is under additional stress or under conditions favorable for rapid herbicide uptake from the soil (i.e., cool, wet spell followed by warm, windy weather).

Leaves Failing To Unfurl

Photosynthetic inhibitors

(mobile within the plant)



How they work: Interfere with photosynthesis by blocking electron transfer, resulting in damage to plant membranes and cell death.

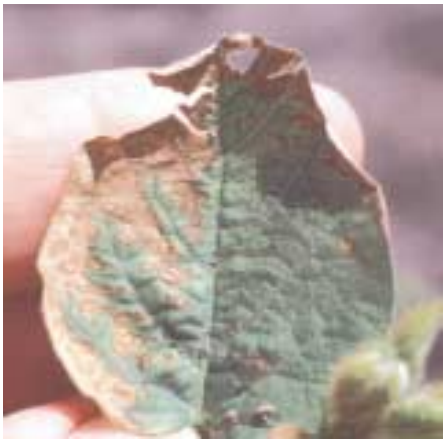
Examples: *atrazine, cyanazine (Bladex), simazine (Princep), metribuzin (Sencor, Lexone)*

Symptoms of injury:

- Herbicides applied to the soil penetrate the root and translocate throughout the plant.
- Oldest leaves turn chlorotic (yellow) first, with veins remaining green longest.
- Plant becomes stunted and may die if enough leaf tissue is affected.

Comments:

Carryover injury is common, particularly in soils with a pH above 7.0. Great variation exists among soybean varieties regarding sensitivity to direct applications of metribuzin, as well as carryover injury. Cyanazine may result in corn injury when applied to corn growing on sandy soils.



Triazine Carryover Injury to Soybean Leaf

Triazine Carryover Injury to Wheat

#2 Soil and Foliar Applied Herbicides

Fasciated Brace Roots

Hormone (auxin)-type herbicides

How they work: Affect growth in the newest stems and leaves by affecting protein synthesis and normal cell division.

Examples: *2,4-D, 2,4-DB, dicamba (Banvel, Clarity), picloram (Tordon), triclopyr (Garlon), triclopyr + 2,4-D (Crossbow), clopyralid (Stinger), MCPA*

Symptoms of injury:

- Stunted, malformed seedlings.
- On older plants, new growth is twisted or malformed.
- Calluses may form on the stem, and plant may lean and become brittle.
- Grass plants exhibit leaf rolling ("onion leafing").

Comments:

Drift, tank contamination, and direct injury are common with most hormone-type herbicides. Carryover injury is possible with picloram but unlikely with the others listed, except in extreme cases of misapplication.

Leaning Corn

ALS enzyme inhibitors

How they work: Normal function of the acetolactate synthase (ALS) enzyme is blocked, inhibiting plant metabolism and cell division (mitosis).

Examples: *imazethapyr (Pursuit), chlorimuron (Classic), imazaquin (Scepter), nicosulfuron (Accent), thifensulfuron (Pinnacle), primisulfuron (Beacon), chlorsulfuron (Glean), flumetsulam (Broadstrike), cloransulam (FirstRate), halosulfuron (Permit), primisulfuron + prosulfuron (Exceed), rimsulfuron + thifensulfuron (Basis)*

Symptoms of injury:

- When applied to the soil, roots often exhibit bottle brush growth (unbranched, stubby), resulting in purple stems and leaves, along with overall plant stunting.
- A soil or foliar application may stop plant growth.
- Leaf tissue becomes light yellow from the outer edge of the leaf in toward the veins, while veins turn light to dark purple.

Comments:

Carryover injury is possible and depends on soil pH and the environmental conditions governing rate of breakdown in the soil. Overlaps and misapplication can also cause carryover injury. Some corn hybrids and soybean varieties are more sensitive than others and may show stunting from direct applications. Drift and tank contamination injury is possible.

ALS-Darkened Veins on Underside of Soybean Leaf

Imazaquin Carryover

Chlorotic Soybean Leaves

#3 Foliar Applied Herbicides

Meristematic (Lipid) inhibitors

How they work: Block formation of lipids in the shoot (meristem) and roots of grass plants.

Examples: *sethoxydim (Poast), fluazifop (Fusilade), quizalofop (Assure), fenoxaprop (Option), diclofop (Hoelon), fluazifop + fenoxaprop (Fusion), clethodim (Select)*

Symptoms of injury:

- Symptoms are slow to develop.
- Plants become stunted when new plant growth is stopped; the growing point of the plant disintegrates and dies first.

Necrotic Meristem

Comments:

Carryover is not likely at normal application rates. Tank contamination and drift injury can affect sensitive species. Direct injury to a crop is most likely to be caused by oils and adjuvants used in combination with these herbicides.

Membrane disrupters

How they work: Disrupt internal cell membranes, and keep the cell from manufacturing energy.

Examples: *acifluorfen (Blazer), lactofen (Cobra), fomesafen (Reflex, Flexstar) flumiclorac-pentyl (Resource).*

Symptoms of injury:

- Water spots develop where herbicide contacts leaf tissue.
- Spots lose color and tissue dies; if sufficient plant tissue is affected, the plant wilts and dies.

Comments:

Carryover injury is not likely, but drift injury can occur from applications made under windy conditions. Direct injury can occasionally be serious if misapplication takes place or the crop is under stress.

Contact Injury

Lactofen

Photosynthetic inhibitors

(nonmobile within plant)

How they work: Block the photosynthetic reaction, and disrupt cellular membranes so that captured light cannot be converted to chemical energy.

Examples: *bentazon (Basagran), bromoxynil (Buctril), paraquat (Gramoxone Extra), pyridate (Tough)*

Symptoms of injury:

- Foliar applied herbicides penetrate leaves, then move a little within the leaf so that the tissue surrounding spray droplets loses color and dies.
- Plant becomes stunted and may die if sufficient leaf tissue is affected.

Comments:

Carryover is unlikely and drift injury is limited to droplets from nearby applications. Crops show good tolerance to these herbicides, but injury may be increased by the addition of spray additives.

Necrosis of Corn Leaves Exposed to Spray

Necrotic Leaf Burn

Produced by the University of Illinois with funding provided by the National Agricultural Pesticide Impact Assessment Program•Photos in this publication include contributions from Dr. William Curran at Pennsylvania State University and staff at the University of Illinois and Purdue University•To obtain more information contact David Pike•U of I, Cooperative Extension•e-mail DPike@piked2.agn.uiuc.edu

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