HOW HERBICIDES WORK IN TERMS THAT WE CAN ALL UNDERSTAND

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Herbicide mode of action can be a daunting and complex subject. However, a general understanding of how herbicides work and knowledge about weed biology can greatly increase herbicide performance. Several factors affect herbicide performance, such as climatic conditions (Table 1) and herbicide uptake, translocation, metabolism, and mechanism of action (Table 2). These factors are discussed in more detail below, with examples using common herbicides in Table 2.

Herbicide uptake

Herbicide uptake is generally through the roots or through the leaves and stems. While seeds can absorb some herbicide in the water they imbibe, this is fairly uncommon and rarely leads to weed control. Soil-applied herbicides are generally taken up by the roots of broadleaf weeds and the roots and shoots of grass weeds. A couple of plant barriers can reduce herbicide root uptake, such as the casparian strip. The casparian strip is a waxy layer in the root that is somewhat analogous to the waxy cuticle on a leaf surface. Post-emergent herbicides (applied to leaves) must also cross several barriers to be absorbed in the plant, such as the waxy leaf cuticle and cell walls and membranes. Surfactants increase absorption of some post-emergent herbicides by decreasing the surface tension of the spray droplet, thus spreading the droplet over a larger portion of the leaf surface.

Herbicide translocation

Some herbicides are translocated or “piped” in the plant to the target site, while others are considered “contact” herbicides that do not move much from the site of absorption. Contact herbicides tend to act fairly quickly. Translocated herbicides move through the xylem or phloem. In general, the xylem transports water (along with accompanying herbicides) from the roots to new above-ground growth. The majority of soil-applied herbicides are transported in the xylem. The phloem is a transport system made up of living plant tissue. The phloem generally transports sugar and other materials (including herbicides) to areas of new growth in the spring and storage organs in the late summer and fall.

Herbicide metabolism within the plant

Metabolism refers to the ability of a plant to breakdown or degrade herbicides. Selectivity – the ability to control target weeds without significantly injuring the crop – is most often based on metabolism. The crop plant and uncontrolled weeds metabolize the herbicide into a form that is no longer toxic to the plant (called inactivation). The speed of herbicide metabolism is important. For example, grasses metabolize synthetic auxin herbicides such as 2,4-D much faster than broadleaves and therefore are not usually as injured.

Herbicide mechanism of action

Several plant systems or processes are involved in herbicide toxicity in susceptible species. Herbicides block or inhibit processes that are critical for plant growth and survival, such as photosynthesis, cell wall and membrane production, and pigment production. Other herbicides disrupt or otherwise compromise the integrity of plant structures, such as by destroying cell membranes.

Table 1. General effect of climatic conditions on herbicide uptake, translocation, metabolism, and mechanism of action. A "+" indicates an increase in the variable, while a "-" indicates a decrease in the variable.

	Drought	High Moisture	Low Temperature	High Temperature
Root uptake	-	++	-	+
Leaf uptake	--	+	-	+
Translocation	--	+	-	+
Metabolism	-	?	--	++
Mechanism of action	-	?	-	+

Table 2. Summary of herbicide characteristics.

Herbicide group	Examples*	Uptake site	Translocation	Mechanism of action	Selectivity	Symptomology
Cellulose inhibitors	Casoron	Soil	Xylem	Inhibits new root/shoot growth and seed germination	Selected grasses and broadleaves controlled	Affected weeds often don't emerge from soil or re-grow in spring
Inhibition of VLCFAs	Devrinol	Soil	Xylem	Inhibits synthesis of fatty acids and cell division	Selected grasses and broadleaves controlled	Affected weeds often don't emerge from soil or re-grow in spring
Carotenoid biosynthesis inhibitors	Evital	Soil	Xylem	Carotenoid pigment synthesis blocked; cell membranes leak	Selected grasses and broadleaves controlled	Bleaching (whitening) of above-ground vegetation
Synthetic auxins	2,4-D, Stinger, Weedar 64	Primarily post	Phloem (with sugars)	Excess synthetic hormones disrupt cell division and growth	Broadleaves controlled	Twisting of stems and leaves, leaf cupping
Lipid synthesis inhibitors (ACCase inhibitors)	Poast, Select Max, Fusilade	Post	Phloem (with sugars)	Blocked enzyme inhibits lipid production	Grasses controlled	Growing point turns brown, new leaves pull easily
Amino acid synthesis inhibitors (EPSPS inhibitors)	Glyphosate (Roundup and others)	Post	Phloem (with sugars)	Blocked enzyme inhibits amino acid and protein production	Non-selective	Relatively uniform yellowing, followed by necrosis (dead tissue)

* Pesticide labels change frequently. Always read and follow the label prior to any pesticide use.