Herbicide Carryover and Crop Rotation to Corn

Herbicide Persistence

Persistence is the length of time a residual herbicide remains active in the soil. Residual herbicides can extend the duration of weed control, but persistence of the herbicide in the soil can potentially injure subsequent crops that may be sensitive to that herbicide. The major factors affecting persistence can be grouped into three categories: soil characteristics, climatic conditions, and the chemical properties of the herbicide product. Understanding how these variables interact to influence herbicide persistence can help growers to reduce the risk of potential crop injury due to herbicide carryover.[1]

Factors Contributing to Herbicide Persistence and Potential Carryover

The length of time that herbicides can persist in the soil and pose potential risks of injury to rotational crops depends on a wide range of factors. Each factor or combination of factors listed below can potentially contribute to herbicide carryover.

- Soil characteristics
  - » Physical (texture, clay content, organic matter content)
  - » Chemical (pH)
  - » Soil microbial activity
- Climatic conditions
  - » Total amount and distribution of rainfall following application
  - » Temperatures (current and since application)
  - » Soil moisture
  - » Sunlight exposure
- Herbicide chemistry
  - » Half-life
  - » Volatility
  - » Water solubility
  - » Leaching potential
- Herbicide application rate and frequency
- Time interval between herbicide application and rotational crop planting
- Sensitivity of the rotational crop to the herbicide
- Early season vigor of the rotational crop

Soil Characteristics

Soils that are high in organic matter (OM) and clay generally have a greater potential for herbicide persistence, or carryover, due to the high number of binding sites. Herbicides can be adsorbed (bound) to the surface of OM and clay particles, making them temporarily unavailable for plant uptake, for leaching through the soil, or for degradation. Adsorption is greatest in medium- to fine-textured soils with a high percentage (>50%) of clay particles and an OM content of 3% or higher. Soil moisture also influences adsorption. Dry soil has higher adsorption capacity compared to wet soils since water competes with the herbicide for the binding sites.[1,3]

Soil pH can be a major factor affecting herbicide availability and persistence. Triazine and sulfonylurea herbicides are highly influenced by soil pH, becoming more available for plant uptake and persisting longer in soil with a pH of 7.0 or higher, due to reduced binding of the herbicide to soil particles. Imidazolinone and dinitroaniline herbicides are somewhat affected by pH and can become more persistent with a soil pH of 6.0 or lower. For other herbicide chemical families, soil pH may play a role in breakdown but is not considered to be the most important influence on persistence.[2]

Herbicide Carryover and Crop Rotation to Corn

Table 1. Corn following soybean rotational restrictions.[4,6]

Group	Herbicide Site of Action	Active Ingredient	Planting of Field Corn (months after application)
1	Lipid Synthesis Inhibitors	clethodim	1
		fluazifop	2
		quizalofop	4
2	ALS Inhibitors	flumetsulam	0
		thiencarbazone-methyl	0
		imazethapyr	8.5
		chloransulam	9
		chlorimuron	9
3	Microtubule Inhibitors	pendimethalin	0
		trifluralin	12
4	Auxin Inhibitors	2, 4-D	0
		dicamba	0
		clopyralid	0
5	PSII Inhibitors	atrazine	0
		metribuzin	0
9	EPSPS Inhibitor	glyphosate	0
10	GS Inhibitor	glufosinate	0
14	PPO Inhibitors	flumiclorac	0
		lactofen	0
		saflufenacil	0
		flumioxazin	.5 (14 days) to 9*
		fomesafen	10**
		sulfentrazone	4, 10*
		fluthiacet	0
15	Fatty Acid Inhibitors	acetochlor	0
		metolachlor	0
		pyroxasulfone	0
		flufenacet	0
		Dimethenamid-P	0
19	Auxin Transport Inhibitor	diflufenzopyr	0.25 (7 days)
22	PSI Inhibitor	paraquat	0
27	HPPD Inhibitors	isoxaflutole	0
		mesotrione	0
		tembotrione	0
		topramezone	0

*rate dependent, consult product label;
** consult product label for geographic restrictions

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Climatic Conditions

Soil microbes and soil water each play a key role in breaking down herbicides. Therefore, weather is usually one of the driving components of herbicide carryover to susceptible crops, as weather can directly impact both microbial activity and soil moisture. The rate of herbicide degradation generally increases as soil moisture and temperature increase. The majority of herbicide degradation resulting from microbial activity occurs during the summer and early fall after the herbicide is applied. Microbes are most active when soil moisture is between 50% to 100% of field capacity. In low rainfall situations, the rate of herbicide degradation by soil microbes can be slow enough to allow herbicides (e.g., imidazolinone herbicides) to persist into the next season. Since microbial activity essentially ceases at soil temperatures below 40° F, any moisture received during the winter probably will not affect microbial activity. Microbes become more active as the soil warms in the spring, but this warming period may not allow enough time prior to planting to impact herbicide degradation to a large degree. Late spring or summer herbicide applications combined with dry fall weather and a cold extended winter can provide the conditions that may lead to carryover problems.[3]

Herbicide Chemistry

Herbicide half-life is the time it takes for 50% of the herbicide to break down. Half-life, volatility, and several other characteristics of herbicides are influenced by their specific chemistry. Herbicide chemistry and the rate of application can impact the persistence of phytotoxic herbicide residues in the soil. Herbicide families with persistent active ingredients include triazines (atrazine), sulfonylureas (chlorimuron, chloransulam), imidazolinones (imazethapyr), dinitroanilines (trifluralin), and diphenylethers (fomesafen). Most of the herbicides that may carry over to the next season have re-cropping intervals of 9-10 months or longer (Table 1).

Of the persistent herbicides mentioned, corn is tolerant to atrazine and can be planted as a rotational crop without any concerns of injury from atrazine exposure.

Interactions

Soil characteristics, climatic conditions, and herbicide chemistry can also interact to directly affect herbicide persistence. Herbicide products vary in water solubility and leaching potential, two chemical traits which can interact with soil texture and rainfall to influence herbicide persistence. Additionally, the chemical volatility of several herbicide active ingredients (e.g., trifluralin, pendimethalin) can interact with sunlight exposure to influence the rate of degradation and the herbicide persistence.

Corn Injuries from Herbicide Carryover

In corn, injury from fomesafen carryover can cause chlorotic stripes between the leaf veins (Figure 1). Fomesafen herbicide products are used with soybean to help manage tough-to-control weeds such as waterhemp and Palmer amaranth, potentially resulting in multiple herbicide applications and late-season applications. Fomesafen is relatively persistent, and when less than average late-season rainfall is received following application, the product can carry over into the following corn crop. Dry and chilly weather during the fall and winter can reduce herbicide dissipation and contribute to increased carryover problems.

Figure 1. Corn injury from carryover of fomesafen. The primary symptom is striped leaves due to chlorotic or necrotic veins on the leaves.[5]

Herbicide Carryover and Crop Rotation to Corn

The application of sulfonylurea herbicide products containing chlorimuron to soybean can also lead to potential carryover problems in corn (Figure 2). Many herbicides containing sulfonylurea chemistry are labeled for use on both corn and soybeans. Products in this family may persist in the soil, particularly if soil pH is above 7.0 and low rainfall is received after the herbicide application. Although they have the same general chemistry, different sulfonylurea herbicides are used in corn and soybeans, and injury to corn may develop in the season following sulfonylurea herbicide application to soybean fields.

Dinitroaniline herbicide products such as trifluralin function by inhibiting root and shoot growth. Injury to corn can occur due to carryover from an application made the previous season (Figure 3).

Figure 2. Corn injury from carryover of chlorimuron. Chlorimuron corn injury typically appears as reduced root systems, often described as "bottle-brush" roots. Roots might turn brown and grow flat or parallel to the soil surface. Early season symptoms can include purple stems and midribs, stunted internodes below the whorl, or a dead growing point. Mid– to late-season symptoms include shortened internodes, malformed leaves, poor root systems, and pinched ears. Injury from herbicides containing an imidazolinone product may exhibit similar symptoms.[5]

Figure 3. Corn injury from carryover of trifluralin. Stunting and purplish discoloration may occur above ground due to pruned and clubbed seedling roots.[5]

How to Minimize the Chance of Herbicide Carryover

- Always read the herbicide label and follow crop rotation intervals.
- Keep records of which fields received a residual herbicide with dates of application and rates applied.
- Make applications early to control weeds and try to minimize late-season applications.
- Be careful during application to apply the correct rate and avoid boom overlaps in the field.
- If you know conditions are being set up for carryover injury with a persistent residual herbicide, plant the same crop as last year.
- Consider tillage in fall and spring to help dilute herbicide residues and encourage degradation.
- Maintain soil pH of 6.5-7.0 to reduce herbicide carryover potential.

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Sources

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