Cover Crops for Weed Management: Herbicide Persistence and Carryover to Cover Crops

Overview

- Herbicide-resistant weed issues have been escalating in agronomic crop production across the U.S. As a result, farmers have increased their reliance on residual herbicide programs. These programs often include layered residuals with multiple sites of action.
- In addition to residual herbicides, cover crops can be a tool for suppressing herbicide-resistant weeds. Cover crops have the potential to reduce the density and size of weeds early in the growing season, improving herbicide effectiveness and reducing selection for resistance.[1]
- Successful establishment is one of the most important factors in cover crop adoption. However, herbicide carryover from the previous summer cash crop to susceptible cover crop species can hinder establishment and cause reductions in biomass, variable stands or death of the cover crop.
- Any residual herbicide program used before fall cover crop establishment should be taken into account when selecting cover crop species.
- More research is needed to fully understand the response of interseeded cover crops (planted in late June through July into cash crops) to residual herbicides.
- When unsure of how an herbicide will interact with a species in a particular climate and location, a field bioassay can help determine possible outcomes. Collect soil from areas that were treated and areas that were not treated in August. Plant desired cover crop species in the soil, water frequently, and monitor emergence and growth of the cover crop species. This should indicate whether or not fall seeding will be successful. Be sure to do this early enough in the fall so the outcomes are known before seeding cover crops in questionable fields later in the fall.

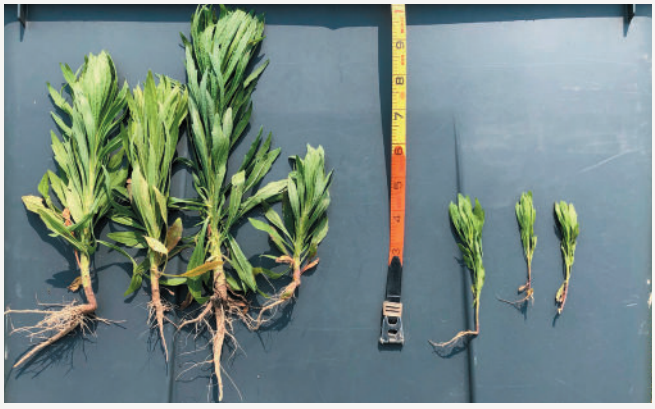

Figure 1. Horseweed collected from plots with no cereal rye (left) and with cereal rye. Photo credit: Wyatt Peterson, Purdue University.[2]

Carryover Risk Factors: External

Herbicide Properties

- Herbicides with higher water solubility are more likely to be moved by water deeper into the soil profile following precipitation or irrigation, thus reducing concentration at the soil surface.
- The inherent characteristics of an herbicide can also influence its ability to be degraded to inactive metabolites by microbial activity or chemical reactions.[2]
- Herbicide half-life, or the amount of time it takes for 50% of the active ingredient to degrade, can be useful when deciding which herbicide within a family to use.
- The product with the lowest half-life may reduce damage to susceptible cover crop species, especially within site of action groups 2 (ALS inhibitors), 14 (PPO inhibitors), 15 (very long-chain fatty acid synthesis inhibitors) and 27 (HPPD inhibitors). More research is needed to better understand cover crop sensitivities to specific herbicide active ingredients.

Soil Characteristics

- Risk of herbicide carryover tends to increase with increasing organic matter and clay content of soils. As a result, higher cation exchange capacity (CEC) levels are also associated with increased carryover.
- Low or high soil pH can increase or decrease herbicide persistence depending on herbicide characteristics.
- Soil microbial activity is one of the most important factors in herbicide breakdown and is highest in warm, fertile, aerated soils with relatively neutral pH.[2]

Weather

- Warmer temperatures and increased rainfall lead to increased rates of herbicide degradation.[2]
- Conversely, herbicide carryover tends to increase under drought conditions or when temperatures are cooler than normal in the months following application.

These factors vary from year to year and field to field and are all interrelated, which can make herbicide persistence difficult to predict. For this reason, half-lives — while helpful for comparing the relative persistence of herbicides — are estimates rather than reliable predictors.

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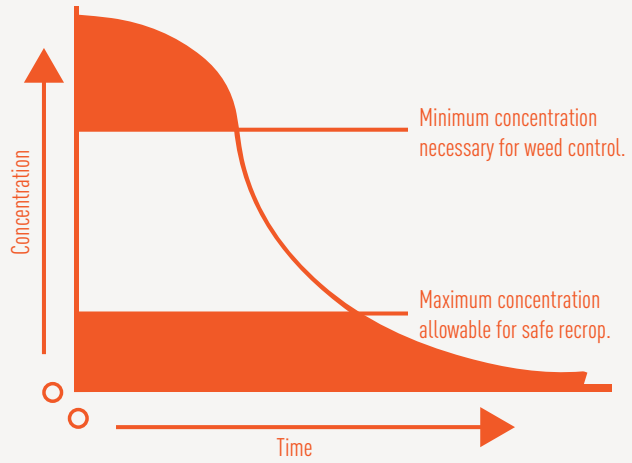

Figure 2. Herbicide dissipation over time. From Curran 2016.[2]

Carryover Risk Factors: Management

Application Timing and Method

- Residual herbicides applied at the time of cash crop planting typically interfere less with cover crop establishment than those applied POST, as there is more time for degradation.
- Incorporating herbicides reduces losses via volatilization and photodecomposition and can increase herbicide persistence.

Tillage

- Tillage can increase degradation via microbial activity and chemical processes but reduce losses from volatilization and photodecomposition.
- No-till systems can increase the amount of herbicides present at the soil surface because of less dilution and less stimulation of microbial activity.[2]

Cover Crop Species Selection

- Herbicides are typically more effective on small-seeded weeds. However, this also means that small-seeded cover crop species are generally more sensitive to herbicide residues.[1]
- Cereal rye and wheat are among the least problematic cover crop species. They can be successfully established following a late corn or soybean harvest and are tolerant to the most commonly used corn and soybean herbicides.

Cover Crop Rotations, Commonly Used Herbicides and Potential Injury

Table 1. Commonly used corn and soybean herbicides, the fall cover crops that are safe to plant in rotation, and cover crop species that may be injured following these herbicides. Adapted from Lingenfelter D. and Curran W., Penn State University.[3,4]

Herbicide Common Name	Group Number	Fall Cover Crops - Safe to Plant	Fall Cover Crops - Potential for Injury
2,4-D	4	All grasses	30 days before sensitive broadleaves
nicosulfuron/nicosulfuron + rimsulfuron	2	Fall cereal grains, ryegrass	Small-seeded legumes, mustards, sorghum
topramezone	27	Wheat, barley, oats, rye after 3 mo.	Many broadleaves are restricted; does not have much soil activity
atrazine	5	Sorghum species	Cereals, ryegrass, legumes, mustards
isoxaflutole	27	Fall cereal grains	Cereals, ryegrass, legumes, mustards
mesotrione	27	All grasses	Small-seeded legumes, mustards
tembotrione + thiencarbazone	27, 2	Wheat, triticale, rye	Small-seeded legumes, mustards, sorghum
dicamba	4	All	Only at high rates or fewer than 120 days
isoxaflutole + thiencarbazone	27, 2	Wheat, triticale, rye	Small-seeded legumes, mustards, sorghum
metolachlor	15	Nearly all cover crops	Ryegrass or other small-seeded grasses
glyphosate	9	All	None
paraquat	22	All	None
thifensulfuron	2	Wheat, barley and oats	None with 45-day waiting interval
acetochlor	15	Most fall cover crops	Food or feed residues rather than crop injury a concern
tembotrione	27	Cereal grains after 4 mo.	Unknown; small-seeded legumes, mustards could be a problem
glufosinate	10	All	None; potential for food or feed residues
metribuzin	5	Cereal grains and ryegrass	Slight risk for small-seeded legumes, mustards
dimethenamid	15	Most fall cover crops	None; potential for food or feed residues
prosulfuron	2	Cereal grains and sorghum	Small-seeded legumes, mustards
halosulfuron	2	Cereal grains and sorghum after 2 mo.	Small-seeded legumes, mustards

Continued

Table 1 continued.

Herbicide Common Name	Group Number	Fall Cover Crops - Safe to Plant	Fall Cover Crops - Potential for Injury
pendimethalin	3	Cereal grains	Small-seeded legumes, ryegrass
flumetsulam	2	Cereal grains	Small-seeded legumes, mustards, ryegrass
rimsulfuron	2	Most fall cover crops	None
saflufenacil	14	All	None
simazine	5	Sorghum species	Cereals, ryegrass, legumes, mustards
clopyralid	4	All grasses	Small-seeded legumes
pyroxasulfone	15	Most fall cover crops	None; potential for food or feed residues
quizalofop	1	Most broadleaves	All grasses if fewer than 120 days or at high rates
sulfentrazone	14	Cereals and ryegrass	Small-seeded legumes, mustards, sorghum
chlorimuron	2	Cereals and ryegrass	Small-seeded legumes, mustards, sorghum
cloransulam	2	Wheat, triticale, rye	Small-seeded legumes, mustards, sorghum
imazethapyr	2	Wheat, triticale, rye, alfalfa, clover	Oats, mustards, sorghum
flumetsulam	2	Cereal grains	Small-seeded legumes, mustards, ryegrass
imazamox	2	Wheat, triticale, rye, alfalfa, clovers	Slight risk for mustards
fomesafen	14	Cereal grains	Small-seeded legumes, mustards, sorghum
imazaquin	2	Cereal grains	Small-seeded legumes, mustards
clethodim	1	All broadleaves	None, assuming at least 30 days
flumioxazin	14	All grasses	Small-seeded legumes, mustards

Cover Crop Sensitivity

- A 2013-2015 study in Missouri evaluated several **corn and soybean herbicides** and cover crops. In general, sensitivity to herbicide carryover, from most to least sensitive, was:
  - Austrian winter pea and crimson clover > oilseed radish > Italian ryegrass > hairy vetch > wheat > winter oat > cereal rye.
  - Relative to other cover crop species evaluated, cereal rye had the least instances of biomass reduction or stand reduction.[5]
- A study in six states across the Midwest found that, in general, sensitivity to residual **soybean** herbicide carryover, from most to least sensitive, was:
  - Forage radish = turnip > ryegrass = winter oat = triticale > cereal rye = Austrian winter pea = hairy vetch = wheat > crimson clover.[6]

Bottom Line

- Overall, the sensitivity of cover crops to herbicide carryover, from most to least sensitive, is currently understood to be:
  - Tillage radish > Austrian winter pea > crimson clover = ryegrass > winter wheat = winter oats > hairy vetch = cereal rye.[7]

Herbicide Injury Potential

- In studies evaluating herbicide carryover to cover crops:
  - **Soybean** herbicides that tended to be most injurious were fomesafen, pyroxasulfone, imazethapyr, acetochlor and sulfentrazone.
  - **Corn** herbicides that tended to be most injurious were topramezone, mesotrione, clopyralid, isoxaflutole, pyroxasulfone and nicosulfuron.[7]
- In general, residual herbicides that control grass weeds can hinder the establishment of grass cover crop species.[8]
- Broadleaf cover crop species tend to be most affected by groups 2 (ALS inhibitors), 5 (photosystem II inhibitors), 14 (PPO inhibitors) and 27 (HPPD inhibitors) herbicides.[8]

Summary

- Some residual herbicides can interfere with the establishment of fall-planted cover crops, while others can be successfully used with cover cropping systems.
- More research is needed to fully understand the response of interseeded cover crops (planted in late June through July into cash crops) to residual herbicides.
- Herbicide programs, soil characteristics and weather patterns should be considered when planning cover crop management and species selection.

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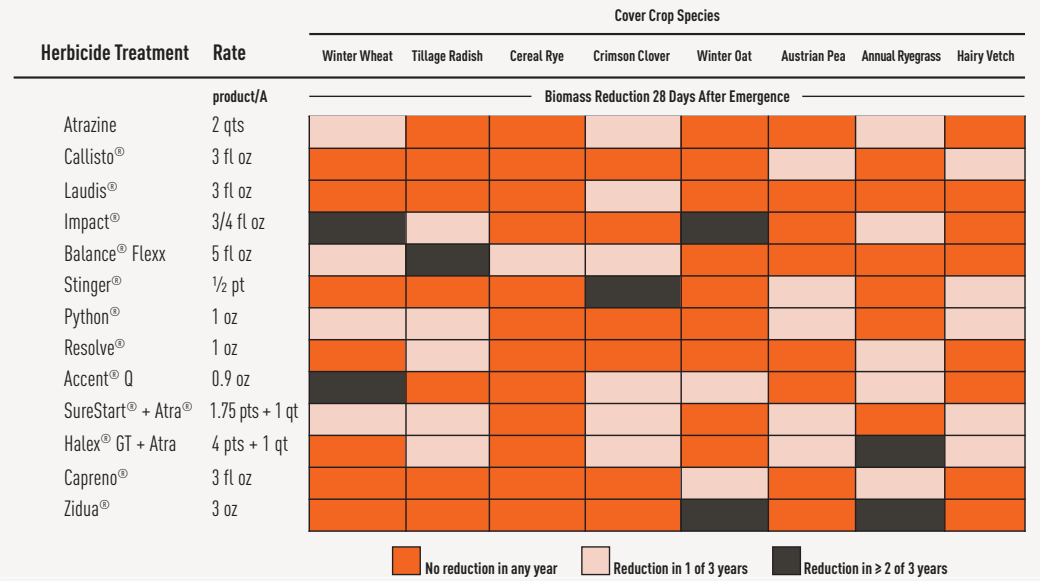
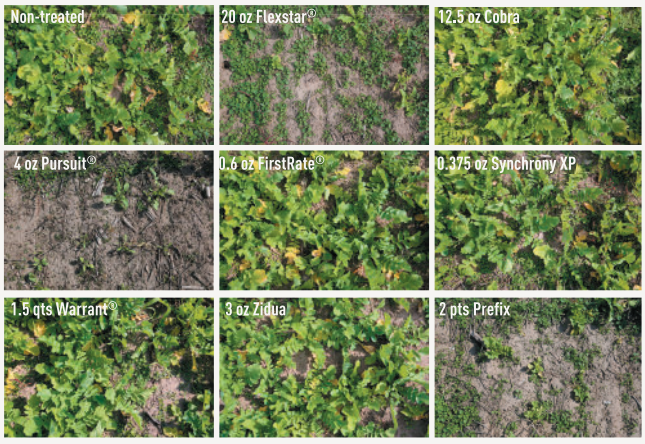
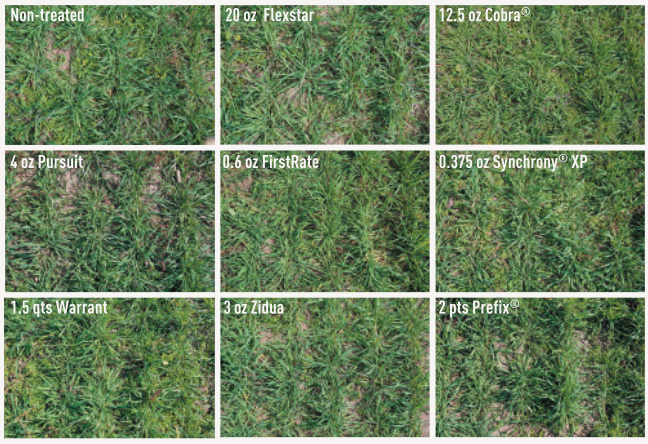


Figure 3. Influence of corn herbicide treatments on fall cover crop biomass. From Cornelius et al. 2017 and Bradley 2020. [5,7]





Figures 4 and 5. Herbicide carryover of POST soybean treatments with product examples to tillage radish (left) and cereal rye. Photo credit: Kevin Bradley, Ph.D., University of Missouri.[7]

[1]Wallace J. (2020). "Integrating Cover Crops for Herbicide-Resistance Management." Take Action webinar.

[2]Curran WS. (2016). Persistence of herbicides in soil. Crops & Soils.

[3]Lingenfelter D, Curran WS. (2017). Corn Herbicides and Rotation to Cover Crops. https://extension.psu.edu/corn-herbicides-and-rotation-to-cover-crops

[4]Lingenfelter D, Curran WS. (2017). Soybean Herbicides and Rotation to Cover Crops. https://extension.psu.edu/soybean-herbicides-and-rotation-to-cover-crops

[5]Cornelius CD, Bradley KW. (2017). Carryover of Common Corn and Soybean Herbicides to Various Cover Crop Species. Weed Technol 31:21-31.

[6]Whalen DM, Bish MD, Young BG, Hager AG, Conley SP, Reynolds DB, Steckel LE, Norsworthy JK, Bradley KW. (2019). Evaluation of cover crop sensitivity to residual herbicides applied in the previous soybean (Glycine max [L.] Merr) crop. Weed Technol 33:312-320.

[7]Bradley KW. (2020). Cover Crop and Herbicide Interactions. https://weedscience.missouri.edu/extension/pdf/2020%20Cover%20Crop%20Data.pdf

[8]Johnson WG, Legleiter TR. (2015). Residual Herbicides and Fall Cover Crop Establishment. Purdue Extension.

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TakeACTION Herbicide-Resistance Management