# Herbicide Persistence and Rotation to Cover Crops

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# Introduction

The question about whether corn or soybean herbicide programs will pose a problem for establishing fall cover crops has become a common question, particularly in areas of severe drought where corn is harvested earlier than normal and the desire to plant a cover/forage crop is strong. If you look at the rotation crop restrictions for corn and soybean herbicides in the Penn State Agronomy Guide (Tables 2.2-17 and 2.4-15), you will see that many products limit rotation to alfalfa and/or the clovers as well as some of the small grains.

This is a good place to start when thinking about rotation to fall cover crops. However, these tables are inadequate because these cash crop rotation restrictions may be due to the concern for herbicide residues accumulating in forage or feed rather than carryover injury. If the crop is not going to be harvested and consumed by livestock or humans, then the primary concern is carryover injury and achieving an acceptable stand that provides the benefits of a fall or winter cover. Cover crops that are not harvested can be planted after any herbicide program, but the grower assumes the risk of crop failure.

Two factors become important when trying to predict the potential for carryover injury to rotational crops.

1. How long the herbicide lasts or persists in the soil, assuming that it has soil activity.

2. How sensitive the rotational crop is to potential herbicide residues.

Herbicides with shorter half-lives (the time it takes for 50% of the active ingredient to dissipate) are always less of a concern.

Of course several factors influence the rate of dissipation such as rainfall, soil texture and soil pH, etc., however, most guidelines generally are for "normal" conditions (e.g. not severe drought). In general, products with a 4 month or less rotation restriction for the species of interest, close relative, or sensitive species (i.e. clovers) should pose little problem. These products typically have half-lives of less than 30 days. Species sensitivity can play a role if only a small amount of residue is necessary to cause injury and the herbicide persists. Quite often, small seeded legumes and grasses like the clovers and ryegrass and mustard species like canola are very sensitive to some herbicides.

The following table provides some persistence and carryover information for some commonly used corn and soybean herbicides.

***Some of this information is our best guess and only pertains to the eastern US, not heavy Midwest soils or the western US where soils have high soil pH and rainfall is lower.***

**Research conducted and used with permission by Bill Curran and Dwight Lingenfelter**

Extension Weed Science, Penn State University
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# Corn

Common corn herbicides, estimated half-lives, cash crop restrictions and potential to injure fall cover crops.

| HERBICIDE | Active Ingredient | Normal Rate/acre | Half Life (days)[1] | Cash Crop Restrictions | Fall Cover Crops | | Other |
|---|---|---|---|---|---|---|---|
| | | | | | OK to Plant | Concern for | |
| 2,4-D 4S | 2,4-D | 1-2 pt | 7 | Plant anything 30 days after application | All grasses | Wait 30 days before planting sensitive broadleaves | Amine formulations more water soluble and can leach into seed zone |
| Accent 75DF/ Steadfast 75DF | nicosulfuron/ nicosulfuron + rimsulfuron | 0.66 oz/ 0.75 oz | 21 | Sensitive crops have 10-18 month restriction | Fall cereal grains, ryegrass | Small seeded legumes, mustards, sorghum | More persistent in high pH soils (> 7) |
| Atrazine 4L | atrazine | 1-2 qt | 60 | Can plant corn, sorghum, and soybean the following year (some products) | Sorghum species | Cereals, ryegrass, legumes and mustards | More persistent in high pH soils (> 7). Rates < 1 lb/acre can allow more flexibility |
| Balance Pro 4L | isoxaflutole | 2 fl. oz | 50-120 | Small seeded legumes and vegetables have a 10 to 18 month restriction | Fall cereal grains | Cereals, ryegrass, legumes and mustards | 15" of total precipitatio required from application to planting rotation crops except soybean, barley, wheat, sorghum, sunflower |
| Callisto (includes Lumax, Lexar, Halex GT) | mesotrione | 3-6 lf. oz | 5-32 | 10 to 18 months for legumes and vegetables | All grasses | Small seeded legumes, mustards | Sequential applications (PRE fb POST) increase the potential for injury |
| Clarity/Banvel 4S (Distinct and Status) | dicamba | 16-24 fl. oz | 5-14 | 15 days per 8 fl. oz/acre for small grains | All crops | Only at high rates or less than 120 days after application | Anything can be planted after 120 days with 24 fl. oz/acre or less |
| Dual II Mag 7.62E/Cinch | metolachlor | 1.67 pt | 15-50 | Labeled for use on many crops | Almost anything | Annual ryegrass or other small seeded grasses | Higher rates and later applications more of a potential problem |
| Capreno 3.45SC | tembotrione + thiencarbazone | 3 fl. oz | 50-120 | Four months for wheat, 10 months for barley, sorghum, oats and alfalfa | Wheat, triticale, rye | Small seeded legumes, mustards, sorghum | 15" of total precipitation required from application to planting rotation crops except wheat |
| Corvus 2.63SC | isoxaflutole + thiencarbazone | 5.6 fl. oz | 50-120 | Four mo. for wheat, 9 mo. for barley and 17 mo. For alfalfa, oats, sorghum, and canola | Wheat, triticale, rye | Small seeded legumes, mustards, sorghum | 15-30" of total precipitation from application to planting for sensitive crops |
| Harness 7E (Degree, Warrant) | acetochlor | 2 pt | 10-20 | Four mo. for wheat and 9 mo. for alfalfa and clovers | Most crops should be fine | Food or feed residues rather than crop injury may be a concern | Nonfood/feed winter cover crops are allowed after corn harvest |
| Impact 2.8SC | topromesone | 0.75 fl. oz | 14 | Alfalfa, canola, soybean and sunflower have a 9 mo. restriction | Wheat, barley, oats, rye are allowed after 3 mo. Ryegrass should also be OK | Although many broad-leaves are restricted, Impact does not have much soil activity | We have not seed this herbicide carryover in PA |
| Laudis 3.5SC | tembotrione | 3 fl. oz | 14 | Four mo. for cereal grains, 10 mo. for sorghum, canola, and alfalfa | Cereal grains after 4 mo. | Unknown - small seeded legumes, mustards could be a problem | Other crops may be seeded after a successful field bioassay |
| Peak 57WG (& Spirit) | prosulfuron | 1 oz | 9-152 | Cash crop restrictions ranged from 10 mo. for soybean and tobacco to 22 mo. for alfalfa and canola | Cereal grains and sorghum are labeled, other grasses | Small seeded legumes, mustards | More persistent in high pH soils (> 7) |
| Permit/Sandea 75DF | halosulfuron | 2/3 oz | 9-27 | Nine mo. for alfalfa, clovers, soybean and 15 mo. for canola | Cereal grains and sorghum after 2 mo. and other grasses | Small seeded legumes, mustards | Halosulfuron also an ingredient in Yukon |
| Resolve 25DF (Resolve Q) | rimsulfuron | 2 oz | 2-4 | Winter cereals have a 3 mo. restriction and many crops are restricted for 10 mo. | Based on short half-life most fall cover crops should be OK in PA | None | More persistent in drought conditions |
| Simazine 4L (Princep) | simazine | 1-2 qt | 60 | Can plant corn, sorghum, and soybean the following year (some products allow others) | Sorghum species | Cereals, ryegrass, legumes and mustards | Cereals, ryegrass, legumes and mustards |
| Stinger 3S (Hornet and Surestart) | clopyralid | 5 oz | 40 | Recrop intervals 10.5 to 18 months for legumes | All grasses | Small seeded legumes | Small seeded legumes |

[1] Herbicide half-life estimates derived from the WSSA Herbicide Handbook, 2007 or other scientific literature.

# Soybean

Common soybean herbicides, estimated half-lives, cash crop restrictions and potential to injure fall cover crops.

| HERBICIDE | Active Ingredient | Normal Rate/acre | Half Life (days)[1] | Cash Crop Restrictions | Fall Cover Crops | | Other |
|---|---|---|---|---|---|---|---|
| | | | | | OK to Plant | Concern for | |
| Assure II/Targa 0.88E | quizalofop | 8 oz | 60 | Most broadleaves OK | Most broadleaves | All grasses | Plant anything after 120 days |
| Authority 75DF (Spartan 4F) | sulfentrazone | 4 oz | 32-302 | 12-24 months for legumes and some vegetables | Cereals and ryegrass | Small seeded legumes, mustards, sorghum | Labeled on tobacco, sunflowers, transplanted tomato |
| Classic 25DF (Canopy, Envive, etc) | chlorimuron | 0.5-2 oz | 40 | 12-30 months for small seeded legumes | Cereals and ryegrass | Small seeded legumes, mustards, sorghum | More persistent in high pH soils (> 7) and with higher soil applied rates |
| FirstRate 84WDG | cloransulam | 0.3-0.6 oz | 8-33 | Four months to wheat, 9 mo. to alfalfa, corn, sorghum and oats, 12 mo. for barley, 18 mo. for tobacco | Wheat, triticale, rye | Small seeded legumes, mustards, sorghum | The restriction for transplanted tobacco is 10 mo. for 0.3 oz/acre. Sugarbeet and sunflower have 30 mo. restriction |
| Pursuit 2S | imazethapyr | 4 fl. oz | 60-90 | Recrop restrictions range from 4-18 months | Wheat, triticale, rye, alfalfa, clover | Oats, sorghum, mustards | Any crop can be planted 40 months after Pursuit application |
| Raptor 1E | imazamox | 5 fl. oz | 20-30 | Recrop intervals range from 3-18 months | Wheat, triticale, rye, alfalfa, clover | Slight risk for mustards | Most cash crops allowed 9 mo. following application |
| Reflex 2E/ Flexstar 1.88E | fomesafen | 1.5 pt | 100 | Recrop intervals range from 4-18 months | Cereal grains | Small seeded legumes, mustards, sorghum | Since fomesafen is often applied postemergence, soil activity can surprise users |
| Scepter 1.5AS | imazaquin | 0.66 pt | 60-90 | Recrop intervals range from 11-18 months | Cereal grains | Small seeded legumes, mustards | Carryover much more of a rish with drought |
| Select 2E | clethodim | 10 oz | 3 days | Most broadleaves OK | Most broadleaves | All grasses | Plant anything after 120 days |
| Valor 51WDG | flumioxazin | 2.5 oz | 12-20 | Recrop restrictions up to 10 mo. for no-till alfalfa, clover and 12 mo. for no-till canola | All grasses | Small seeded legumes and mustards | Based on half-life, all non-food/feed winter cover crops should be OK |

[1] Herbicide half-life estimates derived from the WSSA Herbicide Handbook, 2007 or other scientific literature.

# Corn and Soybean

Common corn and soybean herbicides, estimated half-lives, cash crop restrictions and potential to injure fall cover crops.

| HERBICIDE | Active Ingredient | Normal Rate/acre | Half Life (days)[1] | Cash Crop Restrictions | Fall Cover Crops | | Other |
|---|---|---|---|---|---|---|---|
| | | | | | OK to Plant | Concern for | |
| **Glyphosate 4L** | glyphosate | 0.75-1.25 lb | 47 | No restrictions preemergence | All | None | Glyphosate does not have soil activity at normal use rates |
| **Gramoxone 2S** | paraquat | 2 pt | 1,000 | No restrictions preemergence | All | None | Parquat does not have soil activity at normal use rates |
| **Harmony 50WDG** | thifensulfuron | 1/8 oz | 12 | Any crop can be planted 45 days after application | No restrictions for wheat, barley, oats | None with 45 day waiting interval | Harmony Extra contains tribenuron |
| **Liberty 2.34L** | glufosinate | 22-36 fl. oz | 7 | No restrictions for canola, corn and soybean. Small grains have a 70 day restriction | All | Food or feed residues rather than crop injury may be a concern | Glyphosate does not have soil activity at normal use rates |
| **Outlook 6E** | dimethenamid | 16 fl. oz | 20 | Four month for cereal grains and anything the following spring | Most crops should be fine | Food or feed residues rather than crop injury may be a concern | Nonfood/feed winter cover crops should be OK after corn harvest |
| **Prowl H2O 3.8CS** | pendamethalin | 3 qt | 44 | Wheat and barley after 4 mo. Other rotational crops the following year | Cereal grains | Small seeded legumes and annual ryegrass | We have not seen this herbicide carryover in PA. Nonfood/feed winter cover crops should be OK |
| **Python 80WDG (Hornet and Surestart)** | flumetsulam | 1 oz | 14-120 | Cash crop restrictions from 4 mo. for alfalfa and cereals to 26 mo. for canola | Cereal grains | Small seeded legumes, mustards and annual ryegrass | Cover crops and forage grasses are restricted for 9 mo. |
| **Metribuzin 75DF (Sencor)** | metribuzin | 0.33 lb | 14-60 | Recrop restrictions range from 4-12 months | Cereal grains and ryegrass | Slight risk for small seeded legumes and mustards | Nonfood/feed winter cover crops allowed |
| **Sharpen 2.85SC (Verdict and Optill)** | saflufenacil | 3 fl. oz | 7-35 | Any crop can be planted 4 mo. after application | All | None | This product has been reported more persistent in western Canada |

[1] Herbicide half-life estimates derived from the WSSA Herbicide Handbook, 2007 or other scientific literature.

# *Testing for Herbicide Residues*

**Article written by Bill Curran**
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Herbicides vary in their potential to persist and carryover in soil. Those herbicides that can persist to the next growing season may injure subsequent crops and need to be monitored more closely. Two methods used to determine if harmful herbicide residues might exist are a soil chemical test done at a laboratory and a bioassay done either in the suspect field or in a warm, sunny indoor location, such as a greenhouse. These tests help predict potential herbicide residue problems so that the grower can make better decisions about crop rotation, herbicide selection, planting date, and other cultural practices.

Laboratory analysis involves extracting the herbicide from the soil with the use of specialized equipment to detect very small amounts of herbicide. Laboratories differ in available tests and in the price of the analyses. The cost can range from $150 to $500 per sample or more. Historically, commercial laboratories like A & L, Columbia Food Labs, Midwest Laboratories, and others provided these services. For a more complete list, we suggest doing an internet search for available labs and services in your region. For both laboratory and indoor bioassay tests, soil samples must be collected.


**Bioassay using oats as the indicator species. The container at right is clomazone (command), while container on left is atrazine. Oats have were planted in suspect soils about 3 weeks prior to this photograph.**

The following procedure should be followed:

**SOIL COLLECTION AND PREPARATION**

1. Collect representative soil samples from the suspect field. Samples should be collected at least 6 to 8 weeks prior to planting the desired crop. Take samples from several locations in the field. For the bioassay or laboratory analysis, take 15 to 20 soil cores and combine them to make a composite sample. This sample should represent no more than 10 to 20 acres. Enough areas must be sampled to avoid missing locations with high herbicide residue content. Take separate samples from areas where excessive residues are suspected, such as sprayer turnaround points and end rows. Do not mix these samples with the others.

Sample the soil to a 6-inch depth (or 3 inches for long-term no-till fields). If sampling to 6 inches, consider dividing the samples into 0- to 3-inch and 3- to 6-inch sections for greater accuracy. Be sure to mark on the bags the depths from which the samples came. Approximately 8 pounds of soil (4 quarts) are needed for each bioassay and 2 pounds of soil (about 1 quart) for each laboratory analysis.

2. Sample an area that is not suspect for use as a "check" soil. This soil may be taken from an alternative field, nearby fence row, garden, or other untreated area. Keep this sample separate from others. Many laboratories require a check sample.

3. If doing a laboratory analysis, submit the samples as soon as possible after sampling. If bioassays are to be performed, they should be run on the soil samples as soon as possible after they have been obtained from the field. If samples cannot be assayed immediately, then store the soil in a refrigerator or freezer that is not used for food. If samples are stored in a warm environment, herbicide residue may decrease with time.

## DETECTING HERBICIDE RESIDUES USING A BIOASSAY

The bioassay can help predict potential crop injury. These tests are inexpensive and can be done with a few simple supplies. A bioassay does not measure the amount of herbicide residue present in the soil, but it may indicate whether enough residue is present to harm a sensitive crop. For suspected carryover from an herbicide, you want to use a plant species that is sensitive to the herbicide. The crop you intend to sow may be the best choice for the test. If the mode of action of a specific herbicide is known, that can help in determining crop response and injury symptomology.

For example, if the herbicide inhibits photosynthesis like atrazine, then injury symptoms will first appear on the fully emerged leaves. If an ALS-inhibitor type herbicide like chlorimuron is suspected, the meristems or growing points are affected first and the plants will be stunted. If a pigment inhibitor is suspect, the plants will be white or chlorotic. Include several different species in the bioassay to give a better range of susceptibility. Some potential sensitive crop plants to use for common herbicide groups include the following:

**GROUP 5**
**Photosynthesis inhibitors (atrazine, simazine, etc.):**
alfalfa, clovers, canola, forage radish, annual ryegrass, oats/

**GROUP2**
**Amino Acid/ALS inhibitors (chlorimuron, chlorsulfuron, metsulfuron, imazapyr, imazethapyr, etc.):**
canola, forage radish, alfalfa/clover, sunflower, sorghum

**GROUP 13 or 28**
**Pigment inhibitors (clomazone, isoxaflutole, mesotrione, etc.):**
alfalfa/clover, canola, forage radish

## FIELD BIOASSAY

A field bioassay is conducted by planting one or more strips of a sensitive species in a suspect field. This procedure can be done in the fall or spring, but it is more accurate if performed closer to the planting of the intended crop. Before planting the desired crop, allow the test plants to grow and develop symptoms of injury of any herbicide residues. The strips should be planted in several locations if possible, and include an area that is most suspect and an area that can serve as a check. Choose an appropriate species for the bioassay, such as one of the more sensitive ones listed in this paper. Include several species of differing sensitivity for greater accuracy.

## INDOOR BIOASSAY

The procedure for conducting an indoor bioassay will vary depending on what herbicide residue is of concern. For the indoor bioassay, the procedures for soil collection and preparation, however, are the same.

1. For the indoor bioassay, take the samples and allow them to air dry if needed until they can be worked readily. Do not over dry the samples. If the soil is cloddy, crush the clods into small pieces (the size of a pea or smaller). If the soil contains a high amount of clay, the addition of coarse sand (50 percent by volume) will improve its physical condition. If sand is added, thoroughly mix it with the soil.

2. Plastic deli containers or flats or trays from greenhouse supply companies are appropriate for conducting bioassays. Make sure there are holes in the bottom of the containers to allow water drainage. Fill two or more containers (a set) with soil from each sample. Additional containers will increase the accuracy of the test. Place the soil samples obtained from the 0- to 3-inch depth in one set of containers, and in another set, place the soil obtained from the 3- to 6-inch depth. Follow this procedure for the composite sample and the sample taken from areas where excessive residues are expected. In addition, fill a final set of containers with the check (untreated) soil.

3. Place between 15 and 50 seeds (depending on species and size in each container of soil and cover the seeds with approximately 1 inch of soil. Wet the soil with water but do not saturate it. Place the containers in a warm location (70° to 75°F) where they will receive ample light. Sunlight is essential for the development of the plant as well as for indicating symptoms of herbicide injury. The container should be watered when necessary. Injury symptoms should become apparent within 10 to 25 days after planting. Compare the suspect soil plants with the check soil plants. Look for inhibited growth, stunting, chlorosis/yellowing, necrosis/browning, and plant death.

Contact Penn State Extension Office for assistance in assessing plant injury.

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