How to Make Residual Herbicides Work for You
or
Managing Herbicide Residues

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When applied at recommended rates most herbicides breakdown within a few days or weeks after application and impose no restrictions on cropping options the next year. Some herbicides however do not degrade quickly and can persist in the soil for weeks, months or years following application. The use of residual herbicides can be beneficial as the residues prevent growth of sensitive weed species throughout the season. These residues however can restrict the crops that can be grown in rotation. Understanding the factors that influence carryover and breakdown are key to assessing risk and the appropriate follow crop. If herbicide carryover is suspected, knowing the appropriate sampling procedures and soil tests to obtain will assist in determining and minimizing herbicide carryover.

Factors Affecting Herbicide Carryover

Herbicide Factors

The type of herbicide and the method of application can influence the extent of the residual carryover. Herbicides differ in their physical and chemical properties such as water solubility, volatility and susceptibility to breakdown by sunlight, and microbes. Herbicides are classified into Herbicide Groups based on their mode action. Commonly used persistent herbicides are in Group 2, 3 and 4. Persistence within these Herbicides Groups can vary from a few days to several months. Their method of breakdown also ranges from simple chemical reaction to a more complex microbial degradation.

Herbicide Family	Group	Herbicide	Breakdown	Soil Factors
SU	2	Ally, Muster, Unity	hydrolysis	>pH 7.0
	2	Sundance	hydrolysis microbial	< 4% OM (>pH 7.0)
Imes	2	Pursuit, Odyssey, Absolute, Assert	microbial	<pH 7.0
Sulfo	2	Everest, K2		<pH 7.0 , OM
Dinitro	3	Edge, Treflan, Fortress, etc.	microbial, photodegradation	OM
Phenoxy	4	2,4 D	microbial	n/a
Benzoic	4	Banvel, Dyvel	microbial	n/a
Other	4	Absolute, Curtail M, Eclipse, Lontrel, Prestige, Prevail, Spectrum	microbial	n/a
	4	Accord	microbial	n/a

Herbicide Characteristics

Adsorption

All herbicides bind to the soil particles and organic matter (OM) to some degree. The strength and extent of the binding will affect the persistence and carryover of the herbicide in the soil. Soil factors such as moisture, pH and OM significantly affect the adsorption of herbicides in the soil. Binding of the herbicide to soil particles increases as moisture content decreases and is particularly important for herbicides that are usually weakly adsorbed. Under dry soil conditions the herbicide is bond to the soil and unavailable for breakdown. When soil moisture is adequate the herbicide becomes available for breakdown.

Water Solubility

How easily the herbicide dissolves in the soil water or its water solubility, will determine how readily the herbicide is available for breakdown or leaching. The more water soluble the herbicide, the more readily it can breakdown or leach in the soil. While high solubility in water can reduce the potential for herbicide carryover, other factors such as biological activity and persistence influence the re-crop restrictions.

Volatility

Some herbicides are very volatile and evaporate readily. Phenoxy herbicides such as 2.4-D are relatively volatile; other herbicides that are volatile are triallate (Avadex), trifuralin (Treflan etc.) ethalfluralin (Edge). The more volatile the herbicide, the more quickly it dissipates from the soil. As a result of this characteristic, many of the soil-applied herbicides are incorporated into the soil soon after application to avoid losses due to volatilization.

Herbicide Degradation

Microbial Decomposition

Soil bacteria, algae and/or fungi metabolize some herbicides. This action is enhanced by conditions that favor the growth and multiplication of microorganism. Warm, moist, fertile soil favors the growth of the soil microorganisms and as a result stimulates breakdown of certain herbicides (see Table #1)

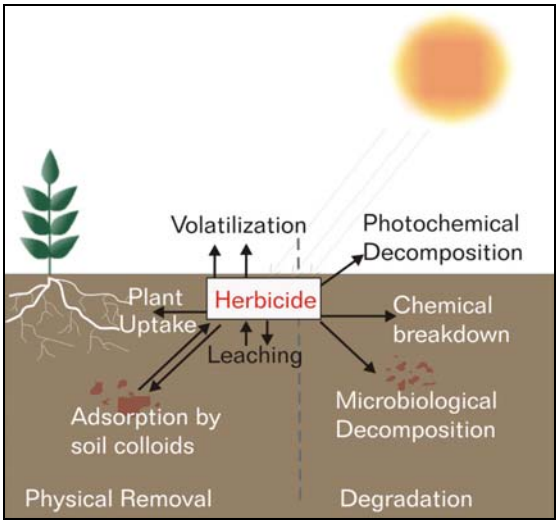


Table # 1

Chemical Degradation:
Some herbicides may react with water or other chemicals in the soil, changing the nature of the molecules responsible for the herbicidal activity. For example, the sulfonylurea (SU) chemically react with water in a process called hydrolysis.Once the SU is in contact with water, the chemical breakdown is initiated, and the herbicide is no longer biologically active.

Photodecomposition
Some herbicide will degrade when exposed to sunlight. When these products are exposed to ultra-violet light on the soil or leaf surface, they breakdown relatives quickly. Herbicides such as trifluralin, ethalfluralin and the cyclohexanones (Poast, Achieve, Select) can degrade in sunlight. Specific management strategies such as soil incorporation and the use of effective surfactants minimize the impact of photo-degradation.

Plant Uptake
Once plants absorb the herbicide, it is metabolized. This effectively removes residues from the soil. When plant stand densities are low, removal of herbicide residues by this method are also low.

Soil Factors

Several soil factors are important in determining the persistence of a herbicide. The extensive variability of such factors as pH, OM and even texture with a field or field-to-field challenge the decision-making process regarding crop selection.

Soil pH
The pH of the soil solution is a critical factor in the breakdown of certain herbicides. Soil pH may cause herbicide degradation directly by affecting the stability of the herbicide or indirectly by its effect on the soil microbes. Many of the Group 2 herbicides are affected by soil pH. The sulfonylureas (SU) herbicides (Refine Extra, Ally, Express, Muster) breakdown more quickly in acid soils, hence persisting longer in high pH soils > pH 7.0. The Imadazolionones breakdown more readily in alkaline soils and therefore persistence is increased in low pH < pH 7.0 soils. Two newer herbicides, Sundance and Everest react similarly to the SU herbicides, the higher the pH the greater the persistence.In addition, OM plays a key role in longevity of the residues.

Organic Matter
Organic matter (OM) can absorb large amounts of herbicides, so the less the OM, the more biologically active the herbicide residue. The organic matter binds the herbicide and releases them more slowly. In high organic soils herbicides persist longer. In addition, soil rich in OM support microorganism, which play a critical role in the degradation of most herbicides.

Soil Texture
The relative percentage of sand, silt and clay in a soil determines its texture. Clay particles provide extensive amounts of surface area that can adsorb significant amounts of herbicide. So in clay soils, herbicide residues tend to be less severe. Since water tends not to move as fast or as deep in clay soils, the potential for herbicide leaching is also diminished, In sandy soils,

herbicide leaching is more significant since the amount of herbicide bond to the soil is less.

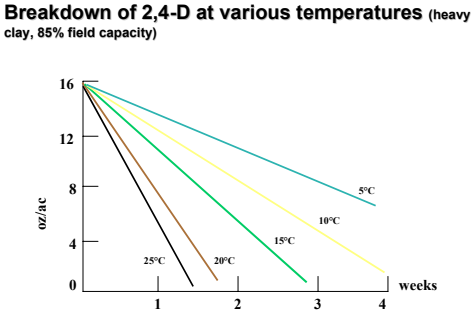
Climatic Factors

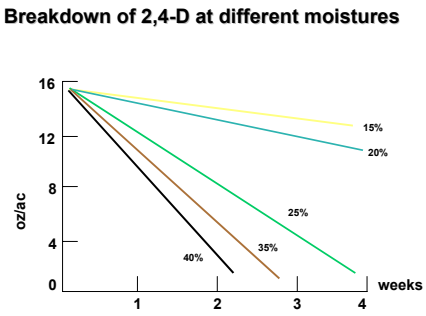
Soil Moisture

Soil moisture is an extremely important factor in determining the rate of breakdown of a herbicide in the soil. The higher the soil moisture levels the higher the rates of leaching, volatilization and microbial/ chemical degradation. The drier the growing season, the greater the potential for herbicide carryover into the following year. The timing of available soil moisture is critical. The rainfall that occurs after the herbicide application can profoundly affect persistence. The less rainfall after spraying, the more likely there will be higher than normal carryover increasing the risk of damage to sensitive crops.

Soil Temperature

In addition to soil moisture, soil temperature is a factor influencing herbicide breakdown. Herbicide residue will disappear more rapidly when the soil is warm >15 C. Early freeze up in the fall and late spring thaw do not allow sufficient time for herbicide breakdown and can result in increased herbicide carryover. The example below illustrates the effect of soil moisture and temperature on the persistence of 2,4-D in the soil (A.Smith, Agriculture Canada, Regina)





Warm, Moist Soils Favor Herbicide Breakdown

Management Factors

Application Rate

The higher the initial application rate, the longer it will take for the herbicide residue to dissipate.

Time of Application

The greater the amount of time between the application and the seeding of a sensitive crop, the less likely injury will occur. Many herbicide labels provide clear guides as to the safe interval. (See Table #2). Following these re-cropping guidelines will minimize the potential of crop damage due to herbicide residues. Fall applications generally involve less risk of rotational crop damage than do spring applications. For example 2,4-D applied in the spring results in greater damage to canola, field peas and lentils than fall applications.

Use Patterns
Consecutive application of the same or related herbicides can increase the risk to rotational crops. The use of residual herbicides from the same Herbicide Group can result in an additive or accumulative effect, potentially limiting crop choices the following year. Keeping good field records and avoid back-to-back use especially of Herbicide Groups 2 and 4. This management strategy will assist in minimizing re-crop concerns.

Uniformity of application/incorporation - Herbicide Group 3 + 8
Residual herbicides that have been applied and incorporated at recommended rates should not be a problem the following season. Non-uniform application or incorporation can cause hot spots where higher than recommended concentrations of herbicide to occur in patches. Damage usually occurs on headlands and corners or in strip throughout the field. Double spraying or not shutting off the sprayer on turns, results in these hot spots.

Tillage System
In direct-seeded fields where minimal disturbance is done, the herbicide residues remain in a concentrated band on the soil surface. In a conventional tillage system, tillage mixes the herbicide residues throughout the soil profile, accelerating rates of microbial degradation and diluting the herbicide residues. Within each system, understanding where the herbicides are assist in managing the seeding of the following year's crop.

Fertility and Plant Growth
Plants absorb herbicides from the soil reducing the concentration in the soil. A good crop stand will absorb the herbicide and in most cases breakdown the herbicide residue (an exception is clopyralid). Plant growth and herbicide decomposition by microbes are influenced by soil fertility. If the soil is low in fertility, the growth of microorganisms and the degradation of herbicides is slower.

Avoiding or Minimizing Herbicide Carry-over Effects

It is important to plan a weed control strategy carefully so that herbicide carry-over can be avoided. Planning a weed control program should be based on the weed problem, herbicide options, including formulation and persistence, soil characteristics, weather conditions and crop rotation. Remember that this plan will have an effect on cropping options in the year(s) ahead.

Always leave an <u>untreated check</u> area in the field for future comparison. Good record keeping is essential to avoid crop losses caused by herbicide carry-over. A weed control plan to minimize or eliminate herbicide carry-over should include:

> **Integrated weed management –** Use various management techniques such as seeding date, crop selection and fertilizer placement to promote a vigorous competitive crop that has an advantage over weeds and helps to minimize the level of carry-over the following year.

Herbicide rotation with crop rotation – This is important in reducing the need to apply herbicides that may carry-over in the soil in successive years. For example, it is not advisable to apply Sundance or Everest to soil treated with Odyssey the previous year.

Selection of herbicides with minimum carry-over potential – Choosing a herbicide with little or no carry-over given your local soil and weather conditions will eliminate future crop injury problems.

Applying minimum rates of herbicides – Theoretically, the rate of herbicide applied should never be more than the amount required to achieve an acceptable level of weed control (this may vary with soil type and moisture conditions). This practice will reduce the potential for carry-over. For example, the amount of trifluralin required on a low organic matter sandy soil is much less than required on higher organic matter clay soils.

Time of application – Research has shown that early removal when the weeds are small reduces competition and improves crop yield. Early season application also assists in reducing the carry-over potential to succeeding crops. The longer the herbicide is exposed to breakdown factors such as, moisture and temperature the lower the risk of carry-over.

Accurate application – Careful and accurate application of herbicide is essential to reduce the potential for carry-over. Always read the label before using, follow all the instructions and precautions, mix the correct amount of active ingredient and ensure the sprayer is properly calibrated and applying uniformly across the boom width. Avoid overlapping on the spray run as this doubles the application rate. And, avoid sharp turns with the sprayer operating as the application rate increases several fold from the inside boom.

Tank-mixture opportunities – Combining a non-residual herbicide with the lowest recommended rate of a residual herbicide in a tank-mixture can reduce carry-over potential. It is important to use only registered tank-mixes and to apply according to the application instructions on the product labels.

Grow a tolerant crop – When herbicide residue is detected or suspected a tolerant crop should be grown. A tolerant crop has the ability to either store or degrade the residue to non-toxic compounds. For example, when carry-over Pursuit is suspected, crops such as canola (non-Clearfield) and flax should be avoided. For specific information read the label for each product used to determine the crops that can be safely seeded in rotation and to determine the length of time before sensitive crops can be grown. Keep in mind that there can be differences in tolerance levels between varieties within a crop.

Soil additives - Adsorption of herbicide residue can be increased by the addition of adsorbent material such as activated charcoal. The use of activated charcoal on a large scale is not economic. However, on small areas as a spot treatment for chemical spills or where high value crops are produced its use might be economically justified.

Application of fertilizer – The addition of fertilizer enhances the growth of tolerant plants, which increases the uptake of herbicide from the soil. It also promotes the growth of microflora, increasing biological breakdown of herbicide in the soil. For example, addition of phosphate enhances the microbial breakdown of the phenoxy herbicides 2,4-D and MCPA.

Determining Herbicide Residues in the Soil

A field bioassay – means growing to maturity a test strip of the crop(s) intended for production the following year. A strip of the same crop grown in an untreated area nearby is a helpful reference. While the field bioassay can provide valuable re-cropping information it is often not practical in many field situations.

A chemical analysis – requires the submission of representative soil samples to a laboratory specializing in the detection of residual herbicide in soil. The chemical analysis determines the amount of herbicide, usually indicated in ppb (parts per billion) remaining in the soil. With a chemical analysis, a zero reading is good news. However, when residue is detected it is difficult to determine the effect the remaining herbicide will have on sensitive crops growing under a range of environmental conditions. Chemical analysis does not correlate to biological activity so is not a good indicator of herbicide carryover risk.

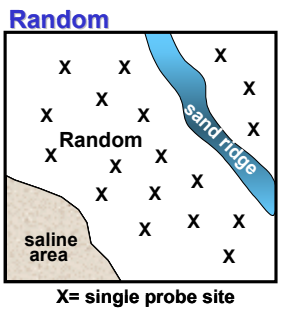
A commercial plant bioassay – involves collecting and sending suspect soil samples to a commercial laboratory where a simple, accurate method is used to determine if it is safe to plant into areas previously treated with herbicides or into soil with an unknown history of herbicide use. It helps in determining if herbicides or other chemical residues are present in soil at concentrations high enough to adversely affect plant growth. It should be conducted (i) when seeding into areas previously treated with residual herbicides (ii) when herbicide stacking is suspected (iii) when environmental conditions, eg extremely dry conditions may cause herbicide residues to persist longer than expected. The plant bioassay should never be used to circumvent the label.

Soil Sampling For Herbicide Residues

The goal in sampling for herbicide residue is to give an assessment of risk for the whole field or "problem" areas. Herbicide carryover is influenced by: soil moisture, soil temperature, pH, organic matter and the herbicide chemistry. When sampling soil for herbicide residues, it is crucial that a representative sample be obtained. Organic matter and pH are variable within a field, often varying due to topographical features of the landscape. The soil sampling techniques listed below are appropriate for herbicide residue detection:

Random Soil Sampling

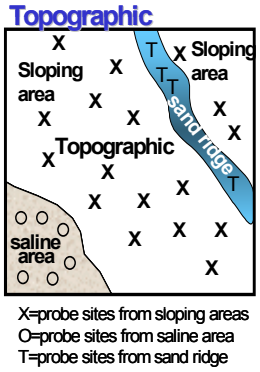
Random sampling is the most common method of soil sampling. Cores need to be collected from the entire area to obtain reliable estimates. For this method to be accurate, the field should not be more than 80 acres in size and been cropped uniformly in the past. Problem areas like, saline spots, poorly drained areas, and



eroded knolls should not be sampled unless they represent a significant portion of the field.

Topographic Soil Sampling

Topographic sampling involves dividing fields into several areas split by landscape position based on topography. When a field is represented by 2 or more topographic areas, each sample should comprise of 15 –20 cores. Separate samples should be taken from; eroded knolls, midslopes of field and low areas with better moisture conditions. This may be a better sampling system for fields where the majority of the field is rolling landscapes. This is also a useful technique in detecting "hot spots" of carryover in the field.



One or both methods may be used on the same field, for example submitting a random sample and topographic sample from the same field.

Sample Requirements

Sample Depth:

- Zero tillage or minimum tillage 0-3"
- Conventional tillage fields 0-6"

Remove thatch from area where the soil sample is taken.

Soil probes or trowel are the most effective

A check or **untreated soil** samples may also be submitted if a herbicide free area can be found. All bioassays are conducted against Alberta Research Council check soils for comparison.

Collect a minimum of **2 kg of soil per sample area.** *(4 standard sized soil sample bags***)** This is enough soil to conduct a bioassay for 3 plant species.

Soil samples should be collected and submitted **prior to fall freeze up**. Samples may also be submitted in the spring (late March-April), but may not have results ready before seeding.

Soil Samples do not need to be dried before submitting. If the soil is very wet at the time of sampling, leave the collected soil to dry until just moist.

All samples should be bagged and tagged separately. Keep samples cool (0 to 5 C) if not being submitted immediately after collection.

Include all relevant information such as field history, sample depth, crop to be grown next year, organic matter, and pH (if available) and sampling method.

A pH measurement of all submitted samples will be conducted, free of charge.

Residual Herbicides and Recropping Restrictions*

Herbicide	*Group*	*Recropping Restrictions*
2,4-D	4	No restrictions the year after application. Caution on spring application prior to broadleaf crops.
Absolute	2, 4	Clearfield canola, wheat (barley submitted to PMRA)
Accord	4	Wheat, barley, canola, field peas, and sunflowers - year after application. Flax and lentils – second year (unless low OM or dry conditions).
Ally	2	Broadleaf crops affected. Dependant on pH – please refer to Guide to Crop Protection.
Assert	2	Black and grey soil zones – wheat, barley canola, peas, flax, sunflowers – one year after application. Canaryseed and oats – two years. Brown and Dark Brown soil zones – wheat, Clearfield canola, barley, sunflowers – one year. Canaryseed, canola, peas, flax, oats – two years after application.
Attain	4	Wheat, barley, oats, rye, forage grasses, flax, canola, mustard, lentils, and peas – one year after application.
Avadex	3	Do not seed tame oats year after application.
Banvel	4	In-crop rates – no restrictions the year after application. Be cautious of fall and spring applications followed by broadleaf crop.
Curtail, Prestige	4	wheat, barley, oats, rye, corn, flax, canola, mustard, forage grasses, sugar beets, and field peas, the year after application.
Eclipse	4, 9	Wheat, oats, barley, rye, forage grasses, flax, canola, mustard can be grown the year after application (field pea not yet registered).
Edge, Treflan,trifluralin	3	Oats, canaryseed, and small-seeded forage grasses may be affected year after application.
Everest/K2	2	Brown soil zone – spring wheat only the year after application. Dark Brown, Black, and Grey soils, spring wheat, barley, canola, and peas can be grown. Do not grow peas if low precipitation and pH>7.5 and OM<4%
Frontline, Spectrum	2, 4	Wheat, barley, canola, and peas can be grown year after application (although not yet registered for Spectrum)
Lontrel	4	Wheat, barley, oats, rye, flax, forage grasses, mustard, and canola can be grown the year after application.
Muster	2	Wheat, barley, oats, and flax can be grown the year after application.
Odyssey	2	Field Peas, Clearfield canola, and spring wheat can be grown the year after application. Barley, canaryseed, oats, and lentils have been submitted for registration to be grown the year after application
Prevail	1, 4	Wheat, barley, oats, rye, corn , flax, canola, field peas, mustard, and forage grasses may be seeded year after application.
Pursuit/Pursuit Ultra	2	Spring wheat, barley, Clearfield canola, peas, lentils, and alfalfa can be grown the year after application. Black and Grey soil zones only. Half rate of Pursuit will have same restrictions as full rate
Sencor	5	Risk of injury with preplant incorporated and higher rates. Risk of injury on fall seeded crops when preplant or postemergent applied.
Sundance	2	Wheat, canola, barley, peas, and flax may be grown year after application. If OM<4% and pH>7, only recrop to wheat or Clearfield canola.

**Refer to the herbicide label and The Guide to Crop Protection* 2002.

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