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Residue Management of Herbicides

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INTRODUCTION

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 herbicide showever 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.

Herbicide half-life

How long will a herbicide persist in the environment? That depends on a lot of factors, but there is a gauge by which we can predict herbicide persistence. Herbicide half-life is a measure of how long it takes for 50% of a chemical to degrade (Table 1). For example, oxadiazon has a half-life of 60 days. So 60 days after application, it will have degraded to ½ of the amount applied. After 120 days, the concentration will have decreased by 50% again so that only ¼ of the applied amount remains. Assuming a 240 day growing season with conditions optimum for herbicide breakdown, only 1/16 of the applied product will remain at the end of the season.

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Herbicide	Rotational Restrictions (Month after application)			
	Winter wheat	Rye	Barley	Alfalfa
2, 4-D	3	3	3	3
Atrazine	24	24	24	24
Pendimethalin	4	9	4	12
Metolachlor	4.5	4.5	4.5	4
Dicamba	1	1	1	6
Imtribuzine	3	18	11	18
Metribuzine	8	12	8	4
Imazathapyr	4	4	4	4

Factors Affecting Herbicide Carryover

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) and trifuralin (Treflan etc.). 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. Warm, moist, fertile soil favors the growth of the soil microorganisms and as a result stimulates breakdown of certain herbicides.

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 reacts 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. These products when exposed to ultra-violet light on soil or leaf surface, they breakdown relatively 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 is 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 in directly by its effect on the soil microbes. The sulfonylureas (SU) herbicides 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. 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.

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 will be the potential for herbicide carryover to the following season. 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: Herbicide residue will disappear more rapidly when the soil is warm >15 ^{o}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. Warm, moist soils favour 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. 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 cumulative effect, potentially limiting crop choices the following year. Keeping good field records and avoid back-to-back use, this management strategy will assist in minimizing re-crop concerns.

Uniformity of application/incorporation: 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 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.

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

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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 untreated check 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 carryover 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.

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.