Remain Aware Of The Potential For Herbicide Carryover In 2013

DR. AARON HAGER

URBANA, ILL.

Ideally, soil-residual herbicides should provide several weeks of weed control but not persist long enough in the soil environment to cause damage to rotational crops. Dry soil conditions, similar to what most of Illinois experienced during the 2012 growing season, often slow the rate of herbicide degradation and increase the potential for damage to rotational crops from herbicide carryover. Some remember the dry growing season of 1998 and the problems encountered in 1989 due to the persistence of one or more soil-residual herbicides that did not adequately degrade in the dry soil conditions of 1988. Will the dry soil conditions during much of the 2012 growing season lead to similar problems with herbicide persistence in 2013? Will the precipitation that was received later in the growing season and throughout the fall eliminate the potential for herbicide carryover? Many factors interact to determine how long a herbicide remains active in the soil environment, including factors related to the herbicide, the soil and climactic conditions.

Herbicides vary in their persistence in the soil; some have very little soil activity (such as thifensulfuron) while others can persist for several months (such as picloram). Variation in soil persistence even can exist among herbicides within a particular chemical family. For example, within the imidazolinone herbicide family, soil persistence of imazamox (Raptor) is much shorter than persistence of imazethapyr (Pursuit). An indication of a herbicide's soil persistence can sometimes be inferred from the crop rotation intervals listed on the respective product label. Herbicides that tend to persist longer in the soil generally have longer crop rotational intervals compared with herbicides that don't persist long. For example, labeled crops may be planted anytime following the application of carfentrazone (Aim), while 10 months must elapse between application of fomesafen (Flexstar) and planting corn. Rotational intervals for a particular herbicide sometimes vary by rotational crop, which also provides an indication of which rotational crops are more sensitive to herbicide residues remaining in the soil. The chemical characteristics of the herbicide molecule that contribute to long soil persistence are inherent properties of the molecule, and there is little that can be done to shorten their persistence once they have been applied. However, variations in certain soil physical and chemical properties can influence the persistence of a particular herbicide apart from its chemical composition.

Soil properties that influence herbicide persistence can be broadly categorized into chemical, physical and microbial. One of the more important soil chemical factors that influences persistence of some herbicides is pH. Soil pH, a measure of the concentration of hydrogen ions present in the soil solution, determines whether a soil is considered acidic, neutral or basic. At higher soil pH values, weakly acidic herbicides, such as many sulfonylurea herbicides, exist in the negatively charged or anionic form. The anionic form is only weakly adsorbed to the clay and organic matter components of the soil, and therefore more of the herbicide remains in the soil solution and available for plant uptake. At lower soil pH values, weakly acidic herbicides exist in the neutral form or, in some instances, the positively charged (or cationic) form. These neutral and cationic forms of the herbicide are more strongly adsorbed to the negative surfaces of clay and organic matter, and therefore are less available for plant uptake.

Soil pH also can impact how much and how quickly certain herbicides are degraded by a chemical process known as hydrolysis. Hydrolysis is a process by which the herbicide molecule reacts with water ("hydro" means water) to cleave ("lysis" means to split or degrade) certain chemical bonds of the herbicide molecule and render it either much less active or herbicidally inactive. The rate of chemical hydrolysis is influenced by the pH of the soil; hydrolysis occurs more rapidly under acidic conditions than under neutral or basic conditions since the weakly acidic herbicide molecule exists in the anionic form under basic conditions and is much less susceptible to hydrolysis. The rate of chemical hydrolysis also can be influenced by soil moisture and temperature, with hydrolysis slowing under dry and cold soil conditions.

Physical properties of soils are related to the relative amounts of sand, silt, clay, and organic matter a soil contains. Soils with higher amounts of clay and organic matter have a greater potential for herbicide carryover than coarse-textured soils or those with less organic matter. Higher amounts of soil organic matter and certain types of clay particles increase the potential for herbicide carryover by adsorbing more herbicide onto these soil colloids. Adsorption is the adhesion of ions or molecules to the surface of soil colloids. Usually these types of attractions are weak such that herbicide molecules move from the colloids into the soil solution in a reversible manner. However, adsorption forces can become stronger over time given certain soil conditions (such as lack of soil moisture). Herbicide bound to soil colloids is not available for plant uptake, movement downward through the soil profile, or microbial degradation. Injury to rotational crops is possible if these bound residues are displaced by water molecules either late in the season they were applied or the following spring.

Soil microorganisms represent the primary method of degradation for many herbicides. These microorganisms include various species of fungi, bacteria, actinomycetes, and algae. The composition of microorganisms (species and abundance) present in a particular soil is influenced by soil type, pH, organic matter content, moisture, etc. Most species of microorganisms are active under aerobic conditions while others thrive under anerobic conditions. Herbicide degradation by microorganisms most often occurs when the microorganisms consume the herbicide molecules as a source of energy. Certain herbicides are more easily degraded by microorganisms than others.

The rate of herbicide degradation by soil microorganisms is often directly related to prevailing environmental and soil conditions. Any condition that impacts the microbial species composition and population can impact the rate of herbicide degradation. Temperature and moisture are two factors that can greatly influence soil microbial populations. The activity level of most soil microorganisms is higher under warmer soil temperatures than under cooler soil temperatures. This partially explains why herbicide degradation tends to slow as soil temperatures drop during the weeks after crop harvest. Minimal herbicide degradation by soil microorganisms occurs when soil temperatures reach approximately 40 degrees Fahrenheit. Herbicide degradation by soil microorganisms usually occurs most rapidly when adequate soil moisture is present. Under extremely dry conditions the rate of herbicide degradation by soil microorganisms can slow enough to allow the herbicide to persist into the next growing season.

What can be done to minimize the risk of injury to rotational crops from residues applied during the previous growing season? In the simplest terms, herbicide degradation simply takes time and moisture. Currently, soil moisture across much of Illinois is more abundant than at this time last year, but the activity of soil microbial populations remains limited at current soil temperatures. Shallow tillage can help distribute herbicide more evenly across a field, and is more likely to help enhance herbicide degradation when soil temperatures are warm and adequate soil moisture is present. Early planting or planting a rotational crop that is very sensitive to the herbicide applied last season might further increase the likelihood of crop injury from herbicide carryover. Ultimately, the susceptibility of the rotational crop determines whether or not persisting herbicide residues will cause any problems. Planting the same crop next season as was planted in 2012 would effectively eliminate the potential for crop injury from herbicide residues. This solution may not be feasible for every situation where herbicide carryover is possible, but it is an option that warrants some consideration. If crop rotation must occur where there is concern for herbicide carryover, delaying planting as long as possible could allow for additional herbicide degradation to occur. Δ

DR. AARON HAGER: Associate Professor, University of Illinois