Environmental Impact on Herbicide Performance

Kim Brown
Manitoba Agriculture and Food, Box 1149, Carman, MB R0G 0J0

In order to be registered in Canada herbicides undergo a rigorous testing procedure to ensure weed control efficacy and crop tolerance. They must be reliable over a range of environmental conditions. Ideally herbicides would act independently of the environment and perform well under all environmental conditions. The action of most herbicides approaches this ideal. In most situations, if you are using the correct herbicide rate, spraying at the correct growth stage, and have good growing conditions for both crop and weeds the results will be satisfactory. However, the action of herbicides can be influenced by environmental conditions. Successful use of herbicides requires knowledge of how environmental conditions prior to, during and after application can affect performance.

Herbicides are subject to both direct and indirect environmental effects. Direct effects can be measured by the amount of retention or penetration of the herbicide, while the effect of the environment on plant growth and development can indirectly influence herbicide performance. Changes in plant growth like leaf thickness or cuticle development will modify how herbicides are retained. Translocation or movement of herbicides within plants is influenced by conditions that impact on plant growth and development. Soil moisture and temperature can alter the effect of soil-applied herbicides. The direct and indirect effects of climatic factors including light, temperature, relative humidity, rainfall, wind and soil moisture will be discussed in detail.

In addition, other influences on herbicide performance such as water quality will be discussed.

Light
High light intensity directly improves penetration into the leaf through open stomata. As light is the energy source for photosynthesis it will influence movement of the herbicide in the plant. Plants that are actively photosynthesizing and transporting sugars will move phloem-mobile herbicides along with them. Certain “dim” herbicides have been found to be unstable in ultraviolet light, and spraying later in the day may help improve efficacy of these grass herbicides.

Light intensity will indirectly effect herbicide performance through many processes. Light stimulates weed seed development and the brightness and amount of light influences leaf shape. Under high light intensity plants tend to have short internodes and many branches; low light intensity tends to produce larger, thinner leaves with thinner cuticles and less wax. These factors will influence the amount of herbicide that penetrates and is retained by the plant.

Temperature
Photosynthesis and respiration are temperature dependent and usually penetration and higher temperatures favor translocation of herbicides in plants. High temperatures tend to favor herbicide action, however at higher temperatures certain herbicides may be less effective. Dicamba can vaporize at temperatures high than 25°C and drift off target, causing less herbicide to be available to the weeds (vapor drift is different from particle drift). High soil temperatures can increase volatility of soil applied herbicides. Microbial breakdown of herbicides in soil tends to be faster under warm conditions.

Temperature can indirectly effect herbicide performance through its effects on plant growth. Germination, growth rate, leaf area, leaf shape, and cuticle development can be influenced by air and soil temperature. Any change in growth or development can influence the amount of herbicide that penetrates and is retained by the plant. Certain herbicides like tralkoxydim can cause crop damage when applied at low temperatures, as the crop is unable to metabolize the herbicide as quickly as usual.
Relative Humidity
High relative humidity can increase foliar penetration of herbicides. Stomata may be open longer, cuticles may be softer, and less evaporation of the droplet may directly influence herbicide performance. Indirectly, plants grown under low relative humidity tend to have thicker cuticles and thus herbicide penetration would be less.

Rainfall
Rainfall can directly influence herbicide retention by washing the droplets off leaf surfaces. Certain herbicide formulations are absorbed more quickly than others, for example ester formulations of auxinic herbicides are taken up more quickly while amine and salt formulations are more susceptible to wash-off. Most herbicides have a rainfastness time limit on the label, if not it is assumed that the product could need up to 8 hours. The intensity and duration of rainfall incidents will also affect rainfastness. Dew or light rain may increase herbicide retention by rewetting spray droplets on the leaf.

Indirectly, rainfall influences weed seed germination and weed and crop growth. Timing of rainfall incidents can determine whether herbicide application is performed at the appropriate growth stage. Plants are sometimes sprayed beyond optimum staging as rainfall may delay herbicide application.

Wind
Windy conditions can directly affect herbicide performance by moving spray off and away from plants, reducing herbicide retention. It is not recommended to spray in winds above 15 km/h (9 mph) or in dead calm conditions. Indirectly, windy conditions may increase wettability of the leaves by damaging the cuticle, and application may take place at less than optimum staging if it is delayed by windy conditions.

Soil Moisture
Soil temperature directly influences soil applied herbicides as most require moisture for activation. Microbial breakdown of herbicides in soil is more rapid under moist conditions. However, herbicides can be lost due to surface evaporation or leaching in wet soils. Indirectly, soil moisture affects germination and rate of growth of both weeds and crops, and so can influence the amount of herbicide that is taken up and translocated within the plant.

In conclusion, many climatic factors can influence herbicide performance both directly and indirectly. Environmental conditions leading up to herbicide application will affect the growth and physiology of plants and the amount of herbicide able to be absorbed and translocated through the plant. Climatic factors at the time of herbicide application can directly affect the amount of herbicide that gets into the target plant. After the herbicide has been applied, environmental conditions affecting plant growth and development will influence herbicide movement and breakdown within the plant. Generally the effects of environmental conditions will not greatly influence herbicide efficacy unless weed control is challenged by other factors such as incorrect rates, inappropriate staging, or adverse growing conditions.

Water Quality
Most of the herbicides we use are mixed with water and applied as a spray. Obviously, water quality is an extremely important issue. Two main aspects of water quality are cleanliness and the presence of dissolved minerals.

Cleanliness
Referring to the presence of suspended silt and organic matter, “dirty” water can reduce the effectiveness of certain herbicides. Diquat, paraquat, and glyphosate bind to organic particles in the water and become inactivated. Additionally, dirty water can cause plugging of screens and nozzles in the sprayer and can affect spray uniformity over the boom.
Minerals
In water sources on the Prairies the main cations of concern are calcium (Ca\(^{++}\)), magnesium (Mg\(^{++}\)), and sodium (Na\(^+\)). The main anions are sulphate (SO\(_4\)\(^-\)), chloride (Cl\(^-\)), and bicarbonate (HCO\(_3\)\(^-\)). There are also small amounts of potassium (K\(^+\)), iron (Fe\(^{++}\), Fe\(^{+++}\)), and nitrate (NO\(_3\)\(^-\)). In a water analysis, all the minerals are added together to give the parts per million of total dissolved solids (TDS). TDS is determined by evaporating a sample to dryness and weighing the material left over, a method that is time consuming and expensive. A simpler method is to measure the electrical conductivity (EC). This is a useful approximation of TDS and is expressed in microSiemens per cm (µS/cm) at 25°C. If the EC is less than 500 µS/cm it is unlike that efficacy of any herbicides will be affected. Overall, the types of minerals dissolved in water are the most important consideration.

Hard water
Hardness is determined by the amount of calcium and magnesium present and is expressed as calcium carbonate equivalent in parts per million (CaCO\(_3\)). The hardness of surface water is almost directly proportional to the TDS or EC while for groundwater; glacial aquifers tend to produce hard water. Water hardness can reduce the effectiveness of glyphosate and 2,4-D amine. Water quality guidelines for glyphosate include: for low rate (annual grass weeds) use water with maximum 350 ppm CaCO\(_3\), for high rates (perennial weeds) maximum 700 ppm CaCO\(_3\). Addition of ammonium sulphate fertilizer (21-0-0-24) at 3 kg/L of water may help, and reduce the water volume to the minimum required. Water quality guidelines for 2,4-D amine include: use an alternate source of water, use an ester (LV) source if practical, use maximum rate, if using an amine formulation use a non-ionic surfactant at 0.1%v/v. Addition of nitrogen fertilizer will not help overcome antagonism with 2,4-D amine.

Iron
Presence of iron in the spray water can reduce the activity of glyphosate. It may cause physical problems with the sprayer, as iron dissolved in ground water will oxidize when exposed to air. This causes a precipitate to form that can plug screens and nozzles. If possible, use an alternate water source.

Bicarbonate Ions
Bicarbonate ions can antagonize certain herbicides, especially the “dims” (tralkoxydim, clethodim, sethoxydim) and 2,4-D amine. For the “dim” herbicides, avoid using water with more than 500 ppm bicarbonate. If that is not possible, use the maximum recommended rate for the target weed and apply herbicide at the optimum growth stage of the weeds. Addition of ammonium sulphate fertilizer (21-0-0-24) at 0.8 kg/acre or urea-ammonium nitrate fertilizer (28-0-0) at 0.2 L/acre will help reduce antagonism. Guidelines for 2,4-D amine include: use an alternate source of water, use an ester (LV) source if possible, use MCPA amine or ester if possible, use maximum rate of 2,4-D, and if using an amine formulation use a non-ionic surfactant at 0.1%v/v. As with hard water, addition of nitrogen fertilizers does not help antagonism of 2,4-D.

In conclusion, few herbicides are adversely affected by water quality. Generally we see satisfactory results with most herbicides and water sources. Usually problems occur when poor water quality is combined with other factors that reduce weed control.
References


