How Herbicides Work: Part II - Efficacy

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INTRODUCTION

Each year I get numerous complaints about the lack of herbicide effectiveness, or efficacy, from a particular application. There can be many reasons why a given herbicide may not provide acceptable weed control. This is the second of three articles intended to cover herbicide types, efficacy, and environmental fate. This article will describe the difference between pre- and post-emergent herbicides, reasons for lack of efficacy, and how to ensure an herbicide is effective.

PRE- VERSUS POST-EMERGENT HERBICIDES

One of the most basic steps to understanding herbicide efficacy is to understand the difference between pre- and post-emergence strategies. Pre-emergent herbicides prevent weeds from emerging. They are effective at preventing new weeds developing from seeds but are ineffective against vegetatively-propagated weeds developing from rhizomes, stolons, or tubers. Pre-emergent herbicides function by preventing the germinating seedling from producing a viable plant. Most are contact herbicides. Germinating seeds produce a primary root, or radicle, to help anchor the potential seedling and begin water and nutrient uptake. When properly applied, pre-emergent herbicides form a barrier layer in the soil at the level of weed seed germination. As the radicles contact herbicide in the soil, the herbicides stop mitosis (cell division), effectively preventing further root growth. Without a root system, the developing seedling dies. Dormant seeds are not affected by pre-emergent herbicides, and these seeds may remain viable for one or more years before germinating.

Post-emergent herbicides are applied only to visible weeds. Post-emergent contact herbicides are useful for annual weeds. Perennial weeds are best controlled

using a systemic herbicide which can be translocated (transported) to the growing point, even if underground. A few herbicides have both pre- and post-emergent activity.

REASONS FOR LACK OF EFFICACY

Wrong herbicide. Herbicides can be classified as selective or non-selective. Non-selective herbicides will kill either monocots (grasses, sedges, rushes) or dicots (broadleaves). Examples of non-selective herbicides include glyphosate (e.g., Roundup) and glufosinate (Finale). Selective herbicides are effective only for a specific type of weed (e.g., broadleaves only) and are important to remove weeds without harming desirable turf. Choosing an herbicide that cannot be absorbed or properly metabolized by a weed will result in poor efficacy.

Poor timing. Applying herbicides at the right time of year or climatic conditions may make the difference between excellent and poor weed control. Weeds must be actively growing in order to absorb and metabolize herbicide. Herbicides applied during heat or drought stress are often completely ineffective. Post-emergent herbicides applied to foliage as liquids need time to be absorbed by the plant. Rainfall or irrigation may wash off the herbicide unless sufficient time has elapsed since application. Often, a minimum of a few hours is sufficient, though some compounds and climatic conditions may require a day. Conversely, sunny, windy, and low humidity conditions may cause a liquid carrier (water) to evaporate quickly from the leaf surface, preventing sufficient absorption of the chemical.

Poor coverage. Contact herbicides, useful primarily for annual weeds, are not translocated in the plant and kill only those plant parts with which they come into contact. Thorough coverage is important to achieve efficacy. Coverage is greatly dependent on carrier volume for both liquid and granular applications. Coverage with liquid applications also depends on nozzle type and spray pressure. Examples of contact herbicides include diquat (e.g., Reward) and glufosinate. Coverage is less important for systemic herbicides such as 2,4-D, bentazon (e.g., Basagran), and glyphosate which can be translocated (transported) within the plant. However, a weed with little leaf surface area due to mowing or other damage will absorb less herbicide than a weed offering a suitable leaf surface area for absorption.

Insufficient rate. Weeds must absorb sufficient herbicide in order for that herbicide to control the

weed. Occasionally, insufficient herbicide may be applied due to errors in measurement or insufficient coverage. Cutting back on herbicide to save money with the assumption that half the herbicide rate may kill half the weeds is wrong; a complete lack of weed control is likely.

Improper application method. Good application methods are important for getting sufficient herbicide into the weed to exhibit control. Most pre-emergent herbicides need to be watered into the soil either through irrigation or rainfall. Post-emergent granular products need to be applied to wet foliage. Certain herbicides require additives such as surfactants to be effective.

Poor formulation. Herbicides may be used in either liquid or granular forms. Occasionally the formulation can affect weed control. Amines (salt-based forms of a chemical) are less effective than ester formulations during cool weather, though amines work fine during warm temperatures. Granular post-emergent herbicides may be ineffective against certain hard-to-kill weeds because it is difficult to get sufficient herbicide to be absorbed by the weed. Most granular post-emergent herbicides require the granules to be applied to wet foliage. This helps ensure the granules stick to the foliage long enough for a sufficient amount of herbicide to be absorbed. However, many of the granules may bounce or fall off the leaves, particularly if the foliage dries shortly after application and if the herbicide is formulated onto large granules.

Type of weed. Some weeds are inherently difficult to kill with herbicides even though they are not truly resistant. Hairs and thick waxy cuticles on leaf surfaces can prevent much of the herbicide from ever being absorbed. Some perennial weeds have vegetative reproductive structures such as stolons or rhizomes which may not be sufficiently exposed to a single application of an herbicide. New research is finding that in some cases particular biotypes of weeds exist, some of which are naturally less susceptible to a particular herbicide than other populations.

Herbicide resistant weeds. Weed populations may develop resistance to herbicides much as fungal pathogens may become resistant to fungicides. Resistance is most likely to occur when a single compound or compounds with a similar site of action are routinely used. Resistance has been reported and verified in many agronomic crop weeds but is rare in turf. Resistance in turf may be rare because herbicides are not routinely used in most turf areas and because most turf herbicides have multiple sites of action. Some of the most likely chemicals to cause resistance are those with a single site of action such as the fatty acid inhibitors (see "How Herbicides Work: Part I - Chemical Classification" in the previous issue of *The GrassRoots*).

Other factors. Herbicides may occasionally fail due to other factors. Thatch can bind and prevent pre-emergent herbicides from reaching their target. Soil pH, or pH of the water used for mixing and loading, may affect the herbicide. Wind may cause drift; low humidity and high temperatures may cause volatilization; sunlight and high temperatures may cause the water droplets carrying the herbicide to dry on the leaf surface before the leaf can absorb the herbicide. Tank-mixing chemically incompatible products may nullify their activity in the plant. Old product, particularly if it has been subject to wide humidity or temperature changes, especially freezing, may simply have lost its effectiveness. Finally, an herbicide application may actually work to control existing weeds, but several weeks or months later weeds are back. The soil usually contains an abundant supply of weed seed, capable of germinating over a period of years, which allow new plants to germinate to take the place of weeds killed by herbicide.

IMPROVING HERBICIDE EFFICACY

Choose the right herbicide for the weed. Of course, you first need to properly identify the weed to know what type of herbicide is appropriate. The herbicide label will indicate if the weed is controlled. In general, most broadleaf herbicides will control most broadleaf weeds, though some products, combinations, or formulations will perform better than others.

Broadleaf herbicides are usually sold in various combinations because individual compounds may be more effective on certain weeds than other compounds, and because the compounds may have synergistic activity. Synergism is a term that means the result is greater than the expected result of the sum of the individual compounds, in other words, 2 + 2 = 5 instead of 4.

In some cases a specific formulation is useful. For example, control of creeping charlie (*Glechoma hederacea*) and wild or wood violet (*Viola* spp.) is improved when ester formulations of triclopyr are used rather than amine (salt) formulations. The volatility of the ester formulation increases the amount of herbicide that is absorbed by the weed. A similar principle applies for weed and feed products: Use an ester formulation if one is available. Even if the granules fall off the weed leaves, the herbicide may still be absorbed by the weeds as it is volatilized into the air. During high temperature stress periods and when sensitive ornamental plants are nearby, however, esters are not recommended due to their potential non-target phytotoxicity.

Timing. Apply herbicides for control of perennial weeds in the autumn, and, if needed, followed by a second application while the weed is in bloom during the following spring. Spring-only applications can be effective, but with some weeds autumn applications may provide nearly 100% control compared to spring applications (e.g., 80% control). Pre-emergent herbicides need to be applied prior to emergence of the weeds, except for dithiopyr (Dimension) which is effective on germinated crabgrass until it tillers.

Poor coverage. When applying granular formulations, use those products that have small particles rather than large particles. Small particles are more likely to stay on the plant leaf to allow herbicide absorption. Make sure granular products are applied to wet foliage so the granules adhere to the leaves. For liquid products, the foliage needs to be wetted with the product but it is not necessary to apply to the point of leaf runoff. Flat fan nozzles, operating at the

2003 WGCSA Monthly Meeting Schedule

Mon, July 21: Crystal Springs GC, Seymour, WI

Tues, Aug 12: WTA Field Days, OJ Noer Center, Verona, WI

Mon, Sept 22: Nakoma GC, Madison, WI
- Superintendent Tournament
- Speaker Bob Vavrek, "Year in Review"

October 3/4th: Greenwood Hills CC, Wausau, WI
Dinner Dance

Wed, Oct 8: The Bull at Pinehurst Farms, Sheboygan Falls, WI
- WTA Fundraiser Golf Outing

Tues, Oct 14: Racine CC, Racine, WI
- Superintendent/Guest
- Speaker Mark Kuhns "Restoration and Renovation"

Tues/Wed, Nov 18, 19: Symposium American Club, Kohler, WI

manufacturer's recommended pressure and distance from the ground, usually give the best combination of coverage and drift reduction. Hollow or solid cone nozzles are best for spot treatment applications using a backpack sprayer.

Insufficient rate. Pesticide manufacturers spend years and millions of dollars field-testing their products to develop label rates. Usually a label will give a range of the quantity to be used, for example 2 to 4 oz of product per thousand square feet. The proper rate will depend on the type and growth stage of the weed to be controlled. Young, small weeds can often be controlled with lower rates while thick stands of mature weeds, particularly types with vegetative propagules such as rhizomes or stolons, may require the high rate. There is of course no guarantee that even a high rate will eliminate the weeds-sometimes multiple applications are necessary to control hard-to-kill weeds. Preemergent herbicides may be affected by soil type: high label rates may be necessary in organic soils or when a thick thatch layer is present.

Improper application method. Read and follow the label instructions for all pesticides, including herbicides. Some products require the addition of a surfactant such as methylated seed oil or crop oil concentrate to ensure adequate coverage and penetration of the herbicide for weed control. Halosulfuron (Manage) is an excellent product for yellow nutsedge control when a surfactant is added as stated on the label. Some new or revised products are now prepackaged with a surfactant for added efficacy. Applying herbicides on cloudy or overcast days with little wind and moderate temperatures may help avoid evaporation of water droplets from leaf surfaces before the herbicide is absorbed. Low wind conditions will reduce drift, ensuring more of the herbicide is deposited on the target weeds. Make sure to use sufficient carrier volume even if it means an additional trip or two back to the shop to refill the tank. Calibrate your spray equipment at least once annually and repair or replace any leaking hoses or worn nozzles. Finally, keep thorough records of when and where herbicides were used, the amount applied, the calculations you performed to determine the amounts applied and from your calibrations, the product and EPA registration number of the herbicide used, and the weather data during the time of application. The information may be helpful for determining why a particular herbicide application didn't work as well as expected.

Herbicide resistance. Although not a common problem, be aware that herbicide resistance could develop if when herbicides are routinely applied that have a common site of action. Changing herbicides will help prevent resistance.

CONCLUSION

Herbicides are useful tools for suppressing weed populations. However, herbicides are only part of an arsenal for maintenance of a high quality turf, and must be combined with good primary and secondary cultural practices (mowing, fertilizing, irrigation and aeration and topdressing, respectively). Relatively few herbicides are labeled for turf use compared to those available for conventional agriculture. The profit simply isn't there for many products potentially useful for turf. Company mergers in recent years have resulted in few agrochemical companies. The remaining companies are often currently focused on high-profit products with little research devoted to new compounds. Increasing legislative restrictions are causing the loss of some turf herbicides and making it harder for getting new compounds registered. Consequently few new herbicides are being developed. The few new turf products that are undergoing trials are typically products currently registered for conventional agriculture. Research will indicate how effective they are for turf weeds and how they should be used.