Low Use Rates Are the Future for Sulfonylurea Herbicides: Background and Basics

By Clint Waltz and Tim Murphy

It is interesting that at a time when relatively few herbicides are being developed by chemical companies, new herbicides are being introduced into the turf arena. Most of these newly introduced herbicides are in the sulfonylurea (SU) family.

Sulfonylurea herbicides are not new to the turfgrass market. Products like metsulfuron (Manor and Blade) and sulfometuron (Oust) have been used since the 1980s for broad-spectrum weed control in warm-season turfgrasses (Table 1). While the older SUs were broader in the number and type of weeds controlled, the newer SUs are more weed specific with minimal to no phytotoxicity on tolerant grasses. Halosulfuron (Manage) is an excellent example, as it is very effective at controlling problematic sedges like purple nutsedge, yellow nutsedge, and *Kyllinga* species, but is noninjurious on warm- and cool-season turfgrasses.

Sulfonylureas were developed in the mid-1970s by DuPont. This class of chemistry represented a major development in the pesticide industry. In 1989, there were 375 patents issued to 27 agrochemical companies covering tens of millions suspected biologically active structural variations (Brown, 1990).

In 2002, there were 27 SUs listed in the "Herbicide Handbook," which was the largest number of herbicides for any family (WSSA, 2002). Interestingly, only 17 were labeled for use in North America, but since the printing of that publication two SUs (flazasulfuron and foramsulfuron) have been registered or are seeking turfgrass registrations.

Since the mid-1970s, numerous SUs have been synthesized and their herbicidal activity confirmed. Over time, several have been registered for use in the agrichemical market. Because of the great number of potential active ingredients from this class and the relatively short patent periods (17 years), companies have continued to work with this class of chemistry and have released new herbicides often enough to maintain a patent protected chemical on the market.

Characteristics of SU herbicides

Herbicidal activity: The SUs are characterized by high biological activity on susceptible weeds, short half-lives and low toxicities to animal species.

High biological activity is the reason for low use rates associated with this chemistry, which has several advantages such as reducing the amount of active ingredient applied to the environment, reducing handling and container disposal issues. An example of this is the use of halosulfuron for the control of nutsedge compared to the traditional use of MSMA. In a single year, if two applications of halosulfuron were applied at the high label rate (.06 pounds active ingredients per acre, or a.i./A), it would take more than 16 years to equal the amount of active ingredient from one application of MSMA (2 pounds ai/A).

In fact, often two to five annual applications are usually needed for effective control of sedges with MSMA. Sulfonylureas offer a distinct advantage over many other herbicides such as MSMA because effective, weed-specific control can be achieved with "fewer pounds on the ground."

Soil persistence: Under acidic soil conditions, the half-life of herbicides in this family typically ranges from four to 56 days with an average of 35 days (McCarty et al., 1997). Sulfonylurea herbicides are degraded by chemical hydrolysis and microbial breakdown, and both processes are accelerated under acidic conditions.

Additionally, water and soil pH influences the water solubility, sorption to organic matter, and soil mobility of Sus, which have relatively low organic carbon partition coefficient (K_{oc}) values. The K_{oc} value is a measure of a chemical's affinity for the organic carbon component of the soil. A chemical with a high K_{oc} value is more strongly attached to the soil than one with a low value. Photodegradation

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FIGURE 1

Sulfonylurea herbicides labeled or seeking registration for use on turfgrass.

TURFGRASS LABEL	COMMON NAME (lbs ai / acre)	TRADE NAMES (oz product / acre)	FORMULATION	TOLERANT TURF SPECIES
✔	chlorsulfuron (0.05 – 0.25)	Corsair (1 – 5.3)	75 DF	Bahiagrass Bentgrass (fairways) Bermudagrass Fine fescue Kentucky bluegrass
	flazasulfuron*	Katana	25 WG	Bermudagrass Centipedegrass Seashore Paspalum Zoysiagrass
✔	foramsulfuron (0.01 – 0.02)	Revolver (8.8 – 17.4)	2.25 SC	Bermudagrass Zoysiagrass
✔	halosulfuron (0.03 – 0.06)	Manage (0.67 – 1.33) Sempra	75 WP	Bahiagrass Bermudagrass Centipedegrass St. Augustinegrass Fine Fescue Kentucky Bluegrass Tall Fescue
✔	metsulfuron (0.01 – 0.02)	Manor (0.5 – 1.0) Blade Escort	60 DF	Bermudagrass Centipedegrass St. Augustinegrass Zoysiagrass
✔	rimsulfuron (0.02 – 0.06)	TranXit GTA (1 – 4)	25 WSP	Bermudagrass
✔	sulfometuron (0.05 – 0.19)	Oust (1 – 4)	75 DF	Bermudagrass
	sulfosulfuron* (0.04 – 0.06)	Batallion (0.75 – 1.33)	75 DF	Bahiagrass Bermudagrass Zoysiagrass
✔	trifloxysulfuron (0.005 – 0.026)	Monument (0.1 – 0.56)	75 WG	Bermudagrass Zoysiagrass

* Not all herbicides are currently labeled for use on turfgrass. However, this chart represents labeled materials and herbicides being investigated for potential use on turfgrass. Always follow the label recommendations.

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has little impact on this class of herbicides.

At neutral and alkaline conditions, some materials may persist for two years, which may influence the planting of various plant species. Many of the SUs have herbicidal activity on cool-season turfgrass species, like the perennial ryegrass commonly used as an overseeding species on bermudagrass tees, fairways and greens. However, SUs which have short soil half-lives, such as foramsulfuron and rimsulfuron, can be applied for annual bluegrass control 14 days prior to ryegrass overseeding.

Toxicology: Sulfonylureas act upon a specific plant enzyme (acetolactate synthase), which is not found in mammals or other animals (Brown, 1990). For this reason, SUs have very low acute and chronic toxicity. Therefore, they are considered essentially nontoxic to animals.

Mode of action: Herbicides of this family are absorbed by foliage and roots, and inhibit growth at both locations. Once absorbed into the plant, SUs are rapidly translocated acropetally from the root to the shoot, and basipetally from the shoot to the root in the xylem and phloem to the areas of active growth.

Research has shown that SUs work by inhibiting the plant-specific enzyme acetolactate synthase (ALS), which is required for the biosynthesis of branched-chain amino acids. Furthermore, SUs are ALS inhibitors solely and have no influence on other biochemical processes or a second site of activity. This site specificity can lead to the development of SU-resistant weeds, which has been reported after repeated use of chlorsulfuron and metsulfuron in cereal production (Brown, 1990), and sulfometuron for Italian ryegrass control.

Branched-chain amino acids, like valine, leucine and isoleucine are required components of the growth processes of cell division. By blocking ALS and preventing branched-chain amino acid production, sulfonylurea herbicides rapidly inhibit cell division at the root and shoot tips. Studies detected cell division inhibition as quickly as one to two hours after application (Brown, 1990). However, whole-plant symptoms, such as vein reddening, leaf chlorosis and terminal bud death were not evident for several days. Usually one to three weeks are required from the time of application to complete control of the target weed (McCarty, 1997).

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Selectivity: All plants have the enzyme ALS, but not all plants are susceptible to injury from SUs. Differential susceptibility may be because of several factors, including:

1) differential uptake and /or translocation;
2) differential active-site sensitivity; and
3) metabolic inactivation by the tolerant plant.

Although differences in leaf uptake between tolerant and sensitive plants have been measured, it has been concluded these minimal differences are unlikely the principle mechanism of selectivity (Brown, 1990).

Likewise, since SUs are target-site specific, differential active-site sensitivity is not the reason some plants are tolerant and others are not. Most plant physiologists agree that metabolic inactivation, where one plant can inactivate or breakdown the herbicide more quickly than another, is most likely the primary means of selectivity. Tolerant plant species have been shown to metabolize an applied SU in four to six hours, while sensitive species and weedy species have internal plant half-lives more than 50 hours (Brown, 1990).

SUs are generally highly water soluble, so they are subject to tracking and lateral movement to off-target sites.

Potential problems

Because the SUs are generally highly water soluble and have a low K_{oc}, they are subject to tracking and lateral movement to off-target sites.

While one of their positive attributes is having great herbicidal activity at low rates, it can be problematic. It does not take much herbicide to injure sensitive species. Under the right conditions, which would be free water at the soil surface or ponded water on the soil surface shortly following application, these materials can move laterally onto off-target areas. Despite being diluted in the excess water, SUs can still cause extensive damage to sensitive grasses.

Where this problem has occasionally occurred is around creeping bentgrass putting greens, where a turf manager has intended to control annual bluegrass or chemically transition ryegrass right up to the perimeter of the green. Herbicide movement and subsequent injury has occurred when the application was made to saturated clay soils or when an irrigation cycle was used to water in the application but instead washed the diluted herbicide across the green.

In extreme cases, the manager suffered complete loss of bentgrass, but in many incidences the putting green turned yellow and thinned and then recovered. These symptoms typically followed the surface drainage pattern of the putting green.

To prevent these types of problems, read and follow label directions carefully. Use short, frequent irrigation cycles that do not allow water to stand on the soil surface and apply these cycles prior to allowing foot or equipment traffic to cross the treated area to access the putting green. If possible, allow two to three hours after application and irrigation before entry into the treated area. Many of the SUs are rainfast within this time interval, and two to three hours should allow for adequate infiltration of applied water. Do not apply herbicides to areas that are saturated or have standing water.

Summary

From the standpoint of high activity at low use rates and being environmentally benign, the SUs have revolutionized the herbicide industry.

The basic SU molecular structure can be easily altered to produce many derivatives such that designer herbicides can be synthesized to target specific weeds in particular crops. In all likelihood, more SUs will enter the market. In the future, look forward to new herbicides from this class of chemistry that address weed specific problems.

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