

## Broadleaf Weed Control with Sulfonylurea Herbicides in Cool-Season Turfgrass

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Broadleaf weeds are common and troublesome pests in cool-season turfgrass species such as tall fescue, Kentucky bluegrass, perennial ryegrass, and creeping bentgrass. Broadleaf weeds are primarily managed in these grasses through POST applications of growth regulator herbicides in the phenoxy, benzoic acid, and pyridine chemical classes. There are disadvantages to use of these chemicals, including nontarget plant damage and limited residual control. Certain annual broadleaf weeds can be controlled through application of isoxaben or a PRE crabgrass herbicide, but these herbicides do not control emerged broadleaf weeds. There are advantages to use of sulfonylurea herbicides, including PRE and POST control of annual and perennial weeds, a different mode of action, and these herbicides have low vapor pressure, reducing the potential for offsite movement. There are disadvantages to the use of sulfonylurea herbicides, including limited spectrum of broadleaf weed species controlled and limited tolerance in cool-season turfgrass species. The primary sulfonylurea herbicides used in cool-season turfgrass are chlorsulfuron, halosulfuron, metsulfuron, and sulfosulfuron. There have been specialized uses for primisulfuron and tribenuron-methyl.

**Nomenclature:** Chlorsulfuron; halosulfuron; metsulfuron; primisulfuron; sulfosulfuron; tribenuron-methyl; creeping bentgrass, *Agrostis stolonifera* L.; tall fescue, *Festuca arundinacea* Schreb.; perennial ryegrass, *Lolium perenne* L.; Kentucky bluegrass, *Poa pratensis* L.

**Key words:** Annual broadleaf weeds, perennial broadleaf weeds, PRE herbicides, POST herbicides, lawns, seed production.

Las malezas de hoja ancha son plagas comunes y problemáticas en las especies de césped de época fría tales como *Festuca arundinacea*, *Poa pratensis*, *Lolium perenne* y *Agrostis stolonifera*. Las malezas de hoja ancha son manejadas primordialmente en estos céspedes a través de aplicaciones POST de herbicidas reguladores de crecimiento del tipo fenoxi, ácido benzoico y piridina. Existen desventajas del uso de estos químicos, incluyendo el daño a plantas no objetivo y un control residual limitado. Ciertas malezas anuales de hoja ancha pueden ser controladas a través de aplicaciones de isoxaben o un herbicida pre emergente para *Digitaria*, pero estos herbicidas no controlan las malezas de hoja ancha emergidas. Existen ventajas al usar herbicidas sulfonylurea (un modo de acción diferente), incluyendo el control pre-emergente y pos-emergente de malezas anuales y perenes; estos herbicidas tienen baja presión de vapor lo que reduce el potencial de movimiento fuera del sitio de control. Existen desventajas cuando se usan herbicidas sulfonylurea, incluyendo un espectro limitado de control de especies de malezas de hoja ancha y una tolerancia limitada en las especies de céspedes de época fría. Los principales herbicidas sulfonylurea usados en céspedes de época fría son: chlorsulfuron, halosulfuron, metsulfuron y sulfosulfuron. Ha habido usos especializados para primisulfuron y tribenuron-methyl.

Annual and perennial broadleaf weeds are troublesome pest species for those maintaining stands of cool-season turfgrasses. Control programs must be developed by golf course superintendents, sports turf managers, lawn care companies, homeowners, and others maintaining tall fescue, perennial ryegrass, Kentucky bluegrass, creeping bentgrass, and other cool-season turf species. Broadleaf weeds are most commonly controlled using one or more selective herbicides in the growth regulator group of chemicals, including the phenoxy, benzoic, and pyridine herbicide classes (Askew and Hipkins 2011). Members of these classes, including 2,4-D, MCPP, dicamba, triclopyr, clopyralid, fluroxypyr, and aminocyclopyrachlor, often are applied in two- or three-way combinations for broad-spectrum control of many annual and perennial broadleaf weed species. These chemicals, especially when applied in combination, control most annual and perennial broadleaf weed species common to turfgrass. There are disadvantages, however, to use of the growth regulator herbicides. There are concerns with

spray drift, vapor drift, root uptake, and carryover in compost with these chemicals, which can result in nontarget damage to desired broadleaf plants, including ornamental, vegetable, and fruit plantings. In addition, certain broadleaf weed species, such as wild violets, Virginia buttonweed, and lespedeza, are difficult to control with most of the growth regulator herbicides. These chemicals also provide limited soil residual control, thus necessitating additional applications to control later-germinating weeds.

There are limited options for PRE control of broadleaf weeds in cool-season turfgrass. The primary option is isoxaben, which controls certain annual broadleaf weed species, along with control of some perennial broadleaves from seed (Askew and Hipkins 2011; Derr 2011). The chemicals commonly applied for PRE control of crabgrass (*Digitaria* sp.) or annual bluegrass control (*Poa annua* L.), including the dinitroanilines, oxadiazon, dithiopyr, and DCPA, control certain annual broadleaves (Derr 2011). However, isoxaben and the PRE crabgrass herbicides generally do not control perennial broadleaf weeds or established annual species.

There are some advantages of sulfonylurea herbicides compared to the previously discussed herbicide classes used for broadleaf weed control. Sulfonylurea herbicides control

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weeds both from PRE as well as POST applications and have a different mode of action, inhibition of the enzyme acetolactate synthase (ALS), than the growth regulator herbicides or the available PRE herbicides (Senseman 2007). They are systemic in plants, and thus control annual and perennial weeds. Sulfonylureas have low volatility, reducing the potential for offsite movement; low toxicity to animals; and low use rates. They can be combined with products such as 2,4-D for broader spectrum weed control. Therefore, there are opportunities for use of sulfonylurea herbicides in cool-season turfgrass species.

There are disadvantages to the use of sulfonylurea herbicides for broadleaf weed control. They generally have a limited spectrum of broadleaf control compared to growth regulator herbicides. These chemicals are slow-acting, often requiring several weeks for significant control symptoms. For example, Busey (2007) reported that metsulfuron controlled pennywort (*Hydrocotyle* spp.), also called dollarweed, only 20% at 10 d after treatment (DAT), increasing to 60% at 20 d, whereas a 2,4-D plus MCPP plus dicamba combination gave 60% control at 10 d and over 80% control at 20 d after application. There is limited cool-season turf tolerance to certain of the available sulfonylurea herbicides, and labeled grasses generally need to be well-established prior to treatment. For example, flazasulfuron, foramsulfuron, and trifloxysulfuron cannot be used in cool-season turfgrass, and in fact, these herbicides can be used to remove grasses such as perennial ryegrass or tall fescue from bermudagrass and certain other warm-season turf species (Askew and Hipkins 2011). The low-use rates for sulfonylureas require accurate calibration by applicators because overapplication can result in turf damage. There is potential for development of resistance if one utilizes repeated applications of sulfonylurea herbicides. In 2010, there were 43 biotypes resistant to ALS inhibitors in the United States (WeedScience.org 2011).

#### **Sulfonylurea Herbicides Used in Cool-Season Turfgrass.**

There are four sulfonylurea herbicides that commonly are utilized in cool-season turf: chlorsulfuron, halosulfuron, metsulfuron, and sulfosulfuron. In addition, there are two herbicides in this class that have specialized uses: primisulfuron and tribenuron-methyl. There are other acetolactate synthase inhibitors used with cool-season turf, including bispyribac-sodium and penoxsulam, but these chemicals are not sulfonylureas.

*Primisulfuron.* Primisulfuron, sold under the trade name Beacon, has been used on Kentucky bluegrass grown for seed in Idaho under a 24 c label (Anonymous 2010d). It is applied at 0.018 to 0.036 kg ai ha<sup>-1</sup>. The product label lists control of broadleaf plantain (*Plantago major* L.), common chickweed [*Stellaria media* (L.) Vill.], common ragweed (*Ambrosia artemisiifolia* L.), dandelion (*Taraxacum officinale* F. H. Wigg.), henbit (*Lamium amplexicaule* L.), mouseear chickweed [*Cerastium fontanum* ssp. *vulgare* (Hartman) Greuter & Burdet], and white clover (*Trifolium repens* L.).

*Tribenuron-methyl.* Tribenuron-methyl, sold under the trade name Express, has been used in turfgrasses grown for seed in Minnesota, Idaho, Oregon, Washington, and Utah (Anonymous 2004a,b). It is used at 0.008 to 0.017 kg ha<sup>-1</sup> in bentgrass, bluegrass, annual ryegrass, fine fescue, and tall

fescue, with lower rates in perennial ryegrass. The Express label lists control of mustard species (*Brassica* spp.), common chickweed, common groundsel (*Senecio vulgaris* L.), hairy buttercup (*Ranunculus sardous* Crantz), and shepherd's-purse [*Capsella bursa-pastoris* (L.) Medik.] (Anonymous. 2009a).

*Chlorsulfuron.* Chlorsulfuron, sold under the trade name Corsair, has been labeled for use in Kentucky bluegrass, fine fescue, and bentgrass (maintained at more than 1.3 cm) at 0.053 to 0.27 kg ha<sup>-1</sup> (Anonymous 2004c). The product label lists control of sowthistle (*Sonchus* spp.), common chickweed, henbit, yellow rocket (*Barbarea vulgaris* W. T. Aiton), wild mustard (*Sinapis arvensis* L.), buttercup (*Ranunculus* spp.), Carolina geranium (*Geranium carolinianum* L.), common groundsel, musk thistle (*Carduus nutans* L.), prostrate knotweed (*Polygonum aviculare* L.), white clover, and wild carrot (*Daucus carota* L.). The label lists control of tall fescue and ryegrass species. Interestingly, however, a noncrop label for this herbicide, Telar XP, (Anonymous 2010a) lists application rates of 0.013 to 0.026 kg ha<sup>-1</sup> for growth and seedhead suppression of fescue species.

Ferrell et al. (2004, Table 1) reported fair to excellent control of certain broadleaf weeds, including common chickweed, white clover, dandelion, henbit, prostrate knotweed, buckhorn plantain (*Plantago lanceolata* L.), and wild violet (*Viola* spp.), with poor to fair control of Virginia buttonweed (*Diodia virginiana* L.) with chlorsulfuron. Chlorsulfuron at 0.07 and 0.14 kg ha<sup>-1</sup> gave good to excellent control of spotted catsear (*Hypochaeris* spp.), buttercup species, knawel (*Scleranthus annuus* L.), purslane speedwell (*Veronica peregrina* L.), hop clover (*Trifolium aureum* Pollich), and chickweed; and fair to good control of dandelion, plantain, white clover, and violet (Bingham and Shaffran 1982). Dernoeden (1982) reported excellent control of dandelion at 2 MAT but no control at 4 MAT with chlorsulfuron at 0.035 and 0.07 kg ha<sup>-1</sup>. Those two rates gave excellent henbit and white clover control. Ebdon and Jagschitz (1982) observed excellent dandelion and mouseear chickweed control, and good to excellent prostrate knotweed control but poor control (< 70%) of woodsorrel (*Oxalis* spp.) and white clover at 2 MAT with chlorsulfuron at 0.07 and 0.14 kg ha<sup>-1</sup>.

*Halosulfuron.* Halosulfuron, sold under trade names such as SedgeHammer and Halosulfuron Pro, is labeled for use in Kentucky bluegrass, tall fescue, perennial ryegrass, and creeping bentgrass at 0.035 to 0.07 kg ha<sup>-1</sup> (Anonymous 2010b). The primary use in turf for this herbicide is sedge control. A formulation of this herbicide used in crop production, Sandea, lists control of fleabane (*Erigeron* spp.), galinsoga (*Galinsoga* spp.), horsenettle (*Solanum carolinense* L.), wild mustard, common ragweed, and pigweed (*Amaranthus* spp.).

Halosulfuron appears to control a narrower range of broadleaf weeds compared to chlorsulfuron and metsulfuron. Ferrell et al. (Table 1) reported good control of henbit but poor control of several other broadleaf weeds with halosulfuron. Derr (2008, Table 2) reported that halosulfuron and sulfosulfuron reduced water pennywort (*Hydrocotyle umbellata* L.) shoot weight by approximately 85%, similar to that seen

Table 1. Broadleaf weed control with sulfonylurea herbicides (from Ferrell et al. 2004).

	Chlorsulfuron	Flazasulfuron	Foramsulfuron	Halosulfuron	Metsulfuron	Rimsulfuron	Sulfosulfuron	Trifloxysulfuron
Buttonweed, Virginia	P-F <sup>a</sup>	G		P	F			G
Chickweed, common	G	E		P	E	G-E		G
Clover, white	F	E		P	E			
Corn speedwell		P	E	P	G	P	P	E
Dandelion	F-G	G-E			E			G-E
Dichondra		P		P	P			G-E
Henbit	G	G	G	G	G	G	G	G
Knotweed, prostrate	G-E	F	P	P	G-E	P	P	P
Plantain, buckhorn	F-G	P			G-E			
Spotted spurge		F-G		P	E	G-E		G-E
Wild violet	F	G		P				

<sup>a</sup> E = > 90%, F = 70–80%, G = 80–90%, P = < 70% control.

with the other sulfonylurea herbicides tested, but neither herbicide caused significant reductions in shoot weight of ground ivy, Virginia buttonweed, or common blue violet (*Viola sororia* Willd.). Derr (unpublished data) observed fair to excellent control of common groundsel and excellent control of flexuous bittercress (*Cardamine flexuosa* With.) with halosulfuron applied POST at 0.02 to 0.035 kg ha<sup>-1</sup> at 44 DAT in a container trial. In another trial, he observed 40 to 65% common groundsel control, 25 to 78% eclipta control [*Eclipta prostrata* (L.) L.], 45 to 75% creeping woodsorrel (*Oxalis corniculata* L.) control, but only 5 to 20% spotted spurge [*Chamaesyce maculata* (L.) Small] control with halosulfuron applied POST at 0.03 to 0.13 kg ha<sup>-1</sup> at 17 DAT in a container trial (unpublished data). Armel et al. (2009) reported fair to excellent control of smooth pigweed (*Amaranthus hybridus* L.), prostrate pigweed (*Amaranthus blitoides* S. Wats.), and carpetweed (*Mollugo verticillata* L.) with halosulfuron at 0.013 to 0.027 kg ha<sup>-1</sup> in vegetable trials. In that study, sulfosulfuron gave fair to excellent control of pigweed species, and good to excellent control of carpetweed. Tribenuron-methyl gave poor to good pigweed control but poor control of carpetweed.

**Metsulfuron.** Metsulfuron, sold under names such as Manor, Blade, and MSM Turf, is registered for use in Kentucky bluegrass and fine fescue that is established at least one year (Anonymous 2010c); it can be applied at 0.01 to 0.02 kg ha<sup>-1</sup>. The label lists control of common chickweed, bittercress (*Cardamine* spp.), white clover, dandelion, ground ivy (*Glechoma hederacea* L.), parsley-piert (*Aphanes arvensis* L.), prostrate spurge [*Chamaesyce humistrata* (Engelm. ex Gray) Small], lawn burweed (*Soliva sessilis* Ruiz & Pavón) (also

referred to as spurweed), wild carrot, henbit, lespedeza (*Lespedeza* spp.), plantain, and *Oxalis*, among other weeds. Noncrop formulations of this herbicide, including Escort and Patriot, can be applied to tall fescue established at least 2 yr at 0.017 to 0.02 kg ha<sup>-1</sup> for growth and seedhead suppression (Anonymous. 2007).

Warner et al. (1986) reported that metsulfuron at 4.2 g ha<sup>-1</sup> controlled pigweed spp., wild mustard, and common purslane (*Portulaca oleracea* L.), with suppression of Canada thistle [*Cirsium arvense* (L.) Scop.]. At 42 g ha<sup>-1</sup>, metsulfuron controlled bittercress, dogfennel [*Eupatorium capillifolium* (Lam.) Small], henbit, prostrate knotweed, shepherd's-purse, and sowthistle. Ferrell et al. (2004) reported fair to excellent control of certain broadleaf weeds, including Virginia buttonweed, common chickweed, white clover, corn speedwell (*Veronica arvensis* L.), dandelion, henbit, prostrate knotweed, buckhorn plantain, and spotted spurge, with poor control of dichondra (*Dichondra* spp.) (Table 3). Derr (2005, unpublished data) observed 90 to 100% control of white clover with metsulfuron at 0.0026, 0.0052, and 0.042 kg ha<sup>-1</sup> and 89 to 100% reduction in buckhorn plantain stand, but no control of Virginia buttonweed at 27 DAT.

**Sulfosulfuron.** Sulfosulfuron, sold under the trade name Certainty, can be applied to established stands of creeping bentgrass, Kentucky bluegrass, and Kentucky bluegrass blends with perennial ryegrass or fine fescue at 0.026 to 0.039 kg ha<sup>-1</sup> (Anonymous 2009b). When used at higher rates, it controls tall fescue and perennial ryegrass. The product label lists control of lawn burweed, buttercup, common chickweed, white clover, dandelion, and wild mustard, with suppression

Table 2. Shoot fresh weight of four broadleaf weed species as affected by application of sulfonylurea herbicides (from Derr 2008).

Treatment	Shoot fresh weight September 25, 2007, 49 d after treatment				
	Rate kg ai ha <sup>-1</sup>	Ground ivy	Water pennywort	Virginia buttonweed	Common blue violet
Untreated		393.1	101.0	756.2	495.0
Foramsulfuron	0.029	143.5	34.4	374.7	344.3
Trifloxysulfuron	0.029	2.4	17.8	182.2	484.0
Sulfosulfuron	0.067	226.7	17.6	441.7	366.9
Flazasulfuron	0.026	37.0	46.9	642.9	220.0
Halosulfuron	0.053	265.3	11.5	860.3	445.9
LSD (P = 0.05)		145.3	27.4	208.0	115.8



Table 3. Estimates of broadleaf weed control with metsulfuron (Manor) (from Murphy 2000).

Common name	Scientific name	% Control
Bedstraw, catchweed	<i>Galium aparine</i>	30–50
Bitterweed	<i>Helienium amarum</i>	80–90
Burweed, lawn	<i>Soliva pterosperma</i>	90–100
Buttercup	<i>Ranunculus</i> spp.	90–100
Buttonweed, Virginia	<i>Diodia virginiana</i>	50–70
Cancerweed	<i>Salvia lyrata</i>	90–100
Carpetweed	<i>Mollugo verticillata</i>	0
Carrot, wild	<i>Daucus carota</i>	90–100
Catsear, dandelion	<i>Hypochaeris radicata</i>	90–100
Chervil, wild	<i>Anthriscus sylvestris</i>	90
Chickweed, common	<i>Stellaria media</i>	90–100
Chickweed, sticky	<i>Cerastium glomeratum</i>	90–100
Clover, white	<i>Trifolium repens</i>	90–100
Copperleaf, hop hornbeam	<i>Acalypha ostryifolia</i>	75
Coreopsis, tickseed	<i>Coreopsis lanceolata</i>	30–40
Corn salad	<i>Valerinella locusta</i>	40–60
Curly dock	<i>Rumex crispus</i>	90–100
Dandelion	<i>Taraxacum officinale</i>	90–100
Dogfennel	<i>Eupatorium capillifolium</i>	60–70
Field madder	<i>Sherardia arvensis</i>	30–40
Fireweed	<i>Erechtites hieracifolia</i>	70–80
Geranium, Carolina	<i>Geranium carolinianum</i>	50–60
Henbit	<i>Lamium amplexicaule</i>	80–90
Hop clover	<i>Trifolium</i> spp.	50–70
Horsenettle	<i>Solanum carolinianum</i>	30–40
Lespedeza, annual	<i>Lespedeza striata</i>	90–100
Marestail	<i>Conyza Canadensis</i>	80–90
Morningglory, pitted	<i>Ipomoea lacunosa</i>	60
Mullein	<i>Verbascum thapsus</i>	80–90
Musk thistle	<i>Carduus nutans</i>	60–70
Mustard, wild	<i>Brassica</i> spp.	60–70
Pennywort	<i>Hydrocotyle verticillata</i>	80–90
Pigweed	<i>Amaranthus</i> spp.	80–90
Plains coreopsis	<i>Coreopsis tinctoria</i>	90–100
Plantain, blackseed	<i>Plantago rugelii</i>	90–100
Plantain, buckhorn	<i>Plantago lanceolata</i>	90
Poorjoe	<i>Diodia teres</i>	70–80
Purslane, common	<i>Portulaca oleracea</i>	60–70
Ragweed, common	<i>Ambrosia artemesiifolia</i>	30
Ragweed, giant	<i>Ambrosia trifida</i>	75
Ragweed, lanceleaf	<i>Ambrosia bidentata</i>	20–30
Ragwort or groundsel	<i>Senecio obovatus</i> , <i>S. glabellus</i>	90–100
Red sorrel	<i>Rumex acetosella</i>	70–80
Sesbania, hemp	<i>Sesbania exaltat</i>	90
Sida, prickly	<i>Sida spinosa</i>	90
Smartweed, Pennsylvania	<i>Polygonum pennsylvanicum</i>	70–80
Sowthistle	<i>Sonchus asper</i>	70–90
Speedwell, corn	<i>Veronica arvensis</i>	90–100
Spurge, prostrate	<i>Euphorbia supina</i>	90–100
Thistle, yellow	<i>Cirsium horridulum</i>	20–30
Vetch, common	<i>Vicia sativa</i>	90
Woodsorrel	<i>Oxalis</i> spp.s	70–90
Yarrow	<i>Achillea millefolium</i>	70–90

of henbit and ground ivy. Noncrop use on tall fescue is listed on another formulation of this herbicide, Outrider (Anonymous 2009c). Ferrell et al. (2004) reported good control of henbit but poor control of corn speedwell and prostrate knotweed with sulfosulfuron (Table 1). In a 2010 PRE container trial, Derr (unpublished data) observed 36 to 75% reduction in a long-stalked phyllanthus (*Phyllanthus tenellus* Roxb.) stand, no reduction in a spotted spurge stand, and a 38 to 81% reduction in an eclipta stand with sulfosulfuron applied at 0.06 to 0.26 kg ha<sup>-1</sup> at 17 DAT.

There are a limited number of sulfonylurea herbicides for use in cool-season turf, especially tall fescue and perennial ryegrass. Focus has been primarily on sedge and annual/perennial grass control in cool-season turf with the available sulfonylurea herbicides, and less emphasis on broadleaf weed control. Chlorsulfuron, halosulfuron, metsulfuron, and sulfo-sulfuron control a number of annual broadleaf weeds, including members of the composite, mustard, and pink families, such as common groundsel, wild mustard, and common chickweed. Control of perennials such as white clover varies among the available products. Primisulfuron and tribenuron-methyl are used in only certain states producing turfgrass seed.

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