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# Selective Exposure of Yellow Nutsedge (*Cyperus esculentus*), Purple Nutsedge (*Cyperus rotundus*), and False Green Kyllinga (*Kyllinga gracillima*) to Postemergence Herbicides

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Greenhouse experiments were conducted to evaluate the effect of selective herbicide placement on sedge shoot number, shoot weight, and root weight. Sulfentrazone, sulfosulfuron, and trifloxysulfuron were applied to soil only, foliage only, or soil plus foliage. Sulfentrazone provided greater yellow nutsedge and false green kyllinga growth reduction compared to purple nutsedge. Sulfosulfuron provided greater purple nutsedge and false green kyllinga growth reduction compared to yellow nutsedge; these species responded similarly to trifloxysulfuron. Soil and soil plus foliar applications provided the highest level of growth suppression, indicating herbicide–soil contact is required for optimum sedge control with these three herbicides. Future research should evaluate techniques that optimize herbicide–soil contact to improve herbicide efficacy.

**Nomenclature:** Sulfentrazone; sulfosulfuron; trifloxysulfuron; false green kyllinga, *Kyllinga gracillima* Miq.; purple nutsedge, *Cyperus rotundus* L.; yellow nutsedge, *Cyperus esculentus* L.
**Key words:** Foliar absorption, herbicide efficacy, root absorption, sedge control.

Se realizaron experimentos de invernadero para evaluar el efecto de la localización selectiva de herbicida sobre el número de brotes, el peso de estos y el de las raíces de tres especies de malezas. Sulfentrazone, sulfosulfuron y trifloxysulfuron fueron aplicados solamente al suelo, solamente al follaje o al suelo y al follaje. Sulfentrazone proporcionó mayor reducción en el crecimiento de *Cyperus esculentus* y *Kyllinga gracillima* en comparación con *Cyperus rotundus.* Sulfosulfuron proporcionó mayor reducción en el crecimiento de *C. rotundus* y *K. gracillima* en comparación a *C. esculentus*, mientras estas especies respondieron de manera similar a trifloxysulfuron. Las aplicaciones solamente al suelo y al suelo y follaje proporcionaron el más alto nivel de supresión en el crecimiento, indicando que se requiere contacto del herbicida con el suelo para optimizar el control de los brotes de la maleza con estos tres herbicidas. Investigaciones futuras deben evaluar técnicas que optimicen el contacto herbicida-suelo para mejorar la efectividad del herbicida.

Purple nutsedge, yellow nutsedge, and false green kyllinga are common perennial sedges in turfgrass systems and grow best in above-normal soil moisture (Bendixen and Nandihalli 1987; Bryson et al. 1997; McCarty et al. 2008; McElroy et al. 2005a). Although each may survive mowing frequency typical of a golf course fairway, purple nutsedge growth can be suppressed at a fairway mowing height of 1.3 cm, whereas false green kyllinga is able to withstand frequent mowing at 1.3 cm (Bryson et al. 1997; Summerlin et al. 2000). Yellow nutsedge is more commonly observed in higher mowing heights (Summerlin 1997). Each species exhibits prolific vegetative growth and produces rhizomes. Purple and yellow nutsedge also produce basal bulbs and tubers (McCarty et al. 2008; Stoller and Sweet 1987).

Native to India and named for its inflorescence color, purple nutsedge is a rapidly spreading perennial with three-ranked basal leaves typically shorter than the flowering stem (Chase and Appleby 1979; McCarty et al. 2008). Although purple nutsedge is not as widely distributed as other *Cyperus* species, it has been described as the ''world's worst weed'' because it is a serious competitor with more crops than any other weed (Holm et al. 1977). Purple nutsedge can produce seed but basal bulbs and chains of tubers are the primary means of dispersal (Murphy et al. 1992; Stoller and Sweet 1987; Wills 1987).

Native to North America, yellow nutsedge has been described as one of the world's worst weeds (Stoller and Sweet 1987). Yellow nutsedge is able to survive cooler climates and is more widely distributed than purple nutsedge (Martínez-Ochoa et al. 2004; McCarty et al. 2008; Stoller and Sweet 1987). This may be because of its ability to increase tuber starch, sugar, and lipid content in response to temperature (Bendixen and Nandihalli 1987). Yellow nutsedge produces seed, basal bulbs, and tubers (Stoller et al. 1972). Unlike purple nutsedge, yellow nutsedge does not produce tuber chains. Yellow nutsedge is cultivated for edible tubers in southern Europe and Africa (Bryson et al. 2009; Wills 1987).

Native to Asia, false green kyllinga is an aromatic, rhizomatous perennial with the ability to produce fruit below mowing heights $< 1.25$ cm, providing a reproductive advantage in managed turfgrasses (Bryson et al. 1997; McElroy et al. 2002; Summerlin et al. 2000). This weed is similar vegetatively to green kyllinga (*Kyllinga brevifolia* Rottb.) but can be differentiated by seed morphology or flower timing (Bryson et al. 1997). Scale keels of green and false green kyllinga seed are denticulate and smooth, respectively (Bryson et al. 1997). False green kyllinga flow-

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ering is photoperiod-dependent, occurring late summer until frost, whereas green kyllinga flowers during most summer months (Bryson et al. 1997; McCarty et al. 2008).

The incidence of sedge species has increased in recent years in turfgrass systems likely due in part to changes in herbicide programs (Yelverton 1996). Traditionally, MSMA used for POST crabgrass (*Digitaria* spp.) and goosegrass [*Eleusine indica* (L.) Gaertn.] control also controlled *Cyperus* and *Kyllinga* species. With the widespread adoption of PRE herbicides and less dependence on POST herbicides, these species are becoming more prevalent in turfgrass systems.

Sulfentrazone is an aryl triazolinone herbicide developed for PRE and POST weed control in soybean, tobacco, sunflower, sugarcane, and turfgrass (Senseman 2007). Sulfentrazone is a protoporphyrinogen oxidase inhibitor which disrupts cell membranes (Senseman 2007). The sulfentrazone product labels allow application up to 420 g ai $ha^{-1}$ in select cool- and warm-season turfgrass (Anonymous 2010b). Sulfentrazone controls some annual grass and broadleaf weeds as well perennial sedge species including false green kyllinga, green kyllinga, and yellow nutsedge (Anonymous 2010a; McElroy et al. 2005b). Sulfosulfuron is a sulfonylurea (SU) herbicide developed for POST weed control in wheat and turfgrass (Senseman 2007). Select warm- and cool-season turfgrasses have exhibited tolerance to sulfosulfuron up to 105 g $ha^{-1}$ (Anonymous 2010b; Lycan and Hart 2004; Willis et al. 2007). Sulfosulfuron controls certain annual and perennial grass and sedge species including yellow and purple nutsedge and green and false green kyllinga (Anonymous 2010a; Eizenberg et al. 2003). Trifloxysulfuron is another SU herbicide currently registered for POST weed control in cotton (*Gossypium hirsutum* L.), sugarcane (*Saccharum* spp.), and turfgrass (Anonymous 2010c; Brecke and Unruh 2000; Hudetz et al. 2000; Porterfield et al. 2002; Wells et al. 2000). Bermudagrass [*Cynodon dactylon* (L.) Pers.], zoysiagrass (*Zoysia japonica* Steud.) and St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] have exhibited trifloxysulfuron tolerance up to 40 g $ha^{-1}$ (Anonymous 2010c; Teuton et al. 2001; Yelverton et al. 2002). Trifloxysulfuron controls select cool-season grasses; annual and perennial sedges including yellow nutsedge, purple nutsedge, green kyllinga, and false green kyllinga; and numerous broadleaf species (Anonymous 2010c; McElroy et al. 2005b; Yelverton et al. 2002). SU herbicides inhibit acetolactate synthase (ALS). The inhibition of the ALS enzyme results in the disruption of the metabolic process, inhibiting the production of essential amino acids including leucine, isoleucine, and valine required for cell biosynthesis (Senseman 2007).

Herbicide efficacy may be governed by the effect of herbicide placement and site of uptake and action. Effects of selective herbicide placement on sedge control have been previously reported for certain herbicides (McElroy et al. 2003, 2004; Nandihalli and Bendixen 1988; Reddy and Bendixen 1988; Vencill et al. 1995; Wehtje et al. 1997). However, information regarding the response of sedge species to currently available herbicides, including sulfosulfuron and sulfentrazone, is limited. The objective of this research was to determine the effect of POST herbicide placement on purple nutsedge, yellow nutsedge, and false green kyllinga growth.

## Materials and Methods

Greenhouse experiments were conducted to investigate the effect of soil, foliar, and soil plus foliar applications of sulfentrazone, sulfosulfuron, and trifloxysulfuron on false green kyllinga, purple nutsedge, and yellow nutsedge growth. Trials were conducted at North Carolina State University's Method Road Greenhouse Laboratory during 2007 and 2008. Greenhouse temperatures were maintained at 32/24 C day/night and plants received overhead irrigation three times daily. Supplemental lighting (350 µmol $m^{-2}$ $s^{-1}$) was provided with metal halide lamps (1,000 W) to simulate a 16-h day length. The growing medium was a 1 : 1 v/v ratio of river-bottom sand and Norfolk loamy fine sand (thermic Typic Kandiudults) with pH 6.2 and 0.4% humic matter.

Purple and yellow nutsedge tubers (Azlin Seed Service, P.O. Box 914, Leland MS 38756.) were purchased and false green kyllinga rhizomes were collected locally. A single yellow or purple nutsedge tuber or single node from a false green kyllinga rhizome was planted at a 1-cm depth in each pot filled with growing medium (103 $cm^2$ surface area and 1,050 ml vol). Sufficient pots were planted to allow selection of uniform plants at experiment initiation. Plants were fertilized (Peters Professional 20–20–20 water-soluble fertilizer, Scotts-Sierra Horticultural Products Co., 14111 Scottslawn Rd., Marysville, OH 43041) biweekly to provide 2.4 g N $m^{-2}$.

Experiments were initiated 28 d after planting (DAP) at which time purple nutsedge averaged three to five leaves and 5.1 cm in height while yellow nutsedge averaged four to six leaves and 10.2 cm in height. False green kyllinga averaged 6 to 12 leaves and 5.1 cm in height. After treatment, plants were not irrigated for 24 h. Through 30 DAT, daily irrigation was applied to the soil surface by hand, paying careful attention to avoid contacting foliage, which would remove herbicide from the leaf surface, or overirrigate, which would possibly leach herbicides out of the pot. After 30 DAT, overhead irrigation was resumed.

Experiments were conducted as a randomized complete block design with a three by three by three factorial arrangement of treatments with four replications. Factorial levels included three sedge species (purple nutsedge, yellow nutsedge, and false green kyllinga), three herbicide placements (soil only, foliage only, or soil plus foliage) and three herbicide treatments (sulfentrazone, sulfosulfuron, or trifloxysulfuron). Nontreated pots were included for each species. All pots were rerandomized weekly to minimize light and temperature variations in the greenhouse. The experiment was repeated over time with two runs in each of 2 yr.

Foliar and foliar plus soil treatments were applied with a hand-held $CO_2$-propelled sprayer calibrated to deliver 304 L $ha^{-1}$ with a single nozzle (8002E TeeJet® flat fan nozzle, Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60189) at 193 kPa. For foliar treatments, herbicide was prevented from contacting the soil by placing a 2-cm-thick layer of activated charcoal (Clean Carbon, Aquatrols, 5 North Olney Ave., Cherry Hill, NJ 08003) on the soil surface prior to herbicide treatment. Foliage was allowed to dry prior to removing the activated charcoal. Soil treatments were applied by diluting the amount of spray solution that would contact

Table 1. Influence of herbicide and species on shoot number, shoot weight, and root weight reduction averaged over herbicide placement in a greenhouse trial 60 DAT.[a,b]

| Species | Shoot number reduction[c] | | | Shoot weight reduction[d] | | | Root weight reduction[e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sulfentrazone | Sulfosulfuron | Trifloxysulfuron | Sulfentrazone | Sulfosulfuron | Trifloxysulfuron | Sulfentrazone | Sulfosulfuron | Trifloxysulfuron |
| | % | | | | | | | | |
| Yellow nutsedge | 72 | 39 | 82 | 77 | 55 | 86 | 75 | 49 | 71 |
| Purple nutsedge | 32 | 75 | 76 | 52 | 83 | 85 | 51 | 77 | 79 |
| False green kyllinga | 64 | 75 | 82 | 64 | 77 | 78 | 56 | 73 | 81 |
| $LSD_{0.05}$ | 18 | 23 | NS | 16 | 14 | NS | 18 | 11 | 9 |

[a] Abbreviations: DAT, days after treatment.

[b] Herbicide application rate: sulfentrazone (336 g $ha^{-1}$), sulfosulfuron (53 g $ha^{-1}$), trifloxysulfuron (22 g $ha^{-1}$).

[c] Percentage of shoot number reduction, relative to the nontreated.

[d] Percentage of shoot weight reduction, relative to the nontreated.

[e] Percentage of root weight reduction, relative to the nontreated.

the soil surface in 10 ml of tap water and uniformly applying the solution to the soil surface. Herbicide treatments included sulfentrazone (Dismiss®, 480 g ai $L^{-1}$, FMC Professional Solutions, 1735 Market St., Philadelphia, PA 19103) (336 g ai $ha^{-1}$), sulfosulfuron (Certainty®, 75WDG, Monsanto Company, 800 North Lindbergh St., St. Louis, MO 63167) (53 g ai $ha^{-1}$), and trifloxysulfuron (Monument®, 75WG, Syngenta Crop Protection Inc., 410 South Swing Rd., Greensboro, NC 27409) (22 g ai $ha^{-1}$). Sulfosulfuron and trifloxysulfuron treatments included a nonionic surfactant (X-77® Spreader, Loveland Industries, Inc., P.O. Box 1289, Greeley, CO 80632) (0.25%v/v).

The number of emerged shoots was recorded 30 and 60 DAT. At 30 and 60 DAT, shoots were clipped at the soil surface and dried for 96 h at 60 C and 0% relative humidity; weights were then recorded. At 60 DAT, belowground sedge biomass (roots, rhizomes, and tubers) were washed free of soil and dried as previously described; weights were recorded. Percentages of shoot number, shoot weight, and root weight reductions, relative to the nontreated, were calculated in the following way:

$$(((\text{nontreated} - \text{treated})/\text{nontreated}) \times 100)$$

Data were subject to ANOVA ($P = 0.05$). Significant ($P < 0.05$) main effects and interactions are presented accordingly with precedent given to higher-order interactions (Steele et al. 1997). Experimental-run main effects and their interactions were not significant; therefore, data were pooled over runs. Means were separated according to Fisher's Protected LSD ($P = 0.05$).

## Results and Discussion

Significant interactions among herbicide and sedge species limited pooling of data. Pooled across herbicide placement, sulfentrazone reduced yellow nutsedge shoot number and shoot weight greater than its reduction of purple nutsedge (Table 1). Sulfentrazone reduced yellow nutsedge and false green kyllinga shoot number and shoot weight 64 to 77%, relative to the nontreated, whereas purple nutsedge shoot weight and number were reduced ≤ 52%. Further, sulfentrazone reduced yellow nutsedge (75%) root weight to a greater extent than its reduction of purple nutsedge (51%) and false green kyllinga (56%). Previous research has reported acceptable yellow nutsedge and false green kyllinga control with sulfentrazone whereas purple nutsedge control was < 50% (Blum et al. 2000; McElroy et al. 2005b).

Sulfosulfuron reduced purple nutsedge and false green kyllinga shoot number, shoot weight, and root weight greater than for yellow nutsedge (Table 1). Purple nutsedge and false green kyllinga shoot number, shoot weight, and root weight were reduced ≥ 73% whereas yellow nutsedge was reduced ≤ 55%. Contrary to these data, Hart and McCullough (2009) reported sulfosulfuron provided > 85% yellow nutsedge control. Previous research has reported acceptable purple nutsedge and false green kyllinga control with sulfosulfuron (Baumann et al. 2004; Brecke et al. 2007; Eizenberg et al. 2003; Harrell et al. 2009; Yelverton 2008).

Trifloxysulfuron reduced shoot number and shoot weight > 75%, regardless of species. Further, trifloxysulfuron reduced purple nutsedge and false green kyllinga root weight ≥ 79%. Previous research has indicated trifloxysulfuron effectively controls yellow and purple nutsedge as well as green and false green kyllinga (Brecke and Unruh 2000; McElroy et al. 2005; Teuton et al. 2001; Yelverton 2008). Burke et al. (2008) reported trifloxysulfuron effectively reduced yellow and purple nutsedge shoot and root dry weight, although reduction was influenced by plant height at application.

Soil- and soil plus foliar–applied sulfentrazone, sulfosulfuron, and trifloxysulfuron provided greater shoot number, shoot weight, and root weight reduction than foliar applications 60 DAT, averaged over sedge species (Table 2). Further, soil-applied sulfentrazone provided greater shoot number reduction than soil plus foliar applications. Soil-applied sulfentrazone reduced shoot number 95% whereas soil plus foliar and foliar applications provided 66 and 5% shoot number reduction, respectively, relative to the nontreated. Foliar-applied sulfentrazone provided minimal (< 15%) shoot and root weight reduction. Soil-applied sulfentrazone likely provided greater reduction in biomass due to increased amount of root-available sulfentrazone compared to foliar or soil plus foliar applications where sulfentrazone was retained on the foliage. Wehtje et al. (1997) reported foliar-applied sulfentrazone had minimal effect on yellow and purple nutsedge and acceptable control required soil contact. They also reported the amount of sulfentrazone in purple

Table 2. Influence of herbicide and placement on shoot number, shoot weight, and root weight reduction averaged over sedge species in a greenhouse trial 60 DAT.[a,b]

| Placement | Shoot number reduction[c] | | | Shoot weight reduction[d] | | | Root weight reduction[e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sulfentrazone | Sulfosulfuron | Trifloxysulfuron | Sulfentrazone | Sulfosulfuron | Trifloxysulfuron | Sulfentrazone | Sulfosulfuron | Trifloxysulfuron |
| | % | | | | | | | | |
| Soil | 95 | 85 | 99 | 95 | 93 | 100 | 92 | 77 | 86 |
| Foliar | 5 | 12 | 42 | 14 | 23 | 48 | 9 | 44 | 59 |
| Soil plus foliar | 66 | 92 | 98 | 83 | 98 | 100 | 83 | 78 | 86 |
| $LSD_{0.05}$ | 17 | 22 | 14 | 15 | 14 | 14 | 18 | 11 | 10 |

[a] Abbreviations: DAT, days after treatment.

[b] Herbicide application rate: sulfentrazone (336 g $ha^{-1}$), sulfosulfuron (53 g $ha^{-1}$), trifloxysulfuron (22 g $ha^{-1}$).

[c] Percentage of shoot number reduction, relative to the nontreated.

[d] Percentage of shoot weight reduction, relative to the nontreated.

[e] Percentage of root weight reduction, relative to the nontreated.

nutsedge foliage was less compared to yellow nutsedge, possibly indicating purple nutsedge absorbs less sulfentrazone. Although absorbed by roots and shoots, sulfentrazone's mobility in phloem is limited due to rapid foliar dessication. Further, foliar-only applications may provide localized symptoms but may be ineffective for complete or long-term control. In contrast, root-absorbed sulfentrazone is readily translocated to yellow and purple nutsedge foliage (Senseman 2007; Wehtje et al. 1997). Thomas et al. (2005) reported ≥ 39% of root-absorbed sulfentrazone was translocated to leaves of treated plants. These data indicate sulfentrazone activity on false green kyllinga, purple nutsedge, and yellow nutsedge is highly dependent on soil exposure, indicating practices that increase sulfentrazone–soil contact may increase efficacy.

Soil- and soil plus foliar–applied sulfosulfuron provided ≥ 85% shoot number and shoot weight reduction and ≥ 77% root weight reduction 60 DAT (Table 2). Foliar applications provided < 45% shoot number, shoot weight, and root weight reduction. Sulfosulfuron is an ALS-inhibiting herbicide that is root- and foliar-absorbed (Senseman 2007). Although published research is not available comparing the activity of root- and foliar-applied sulfosulfuron, foliar plus soil or soil-only applications of other ALS-inhibiting herbicides have been reported to be more effective than foliar-only applications (Williams et al. 2001). Further, Richburg et al. (1993, 1994) reported soil and soil plus foliar applications of the ALS-inhibiting herbicides imazethapyr and imazapic reduced yellow and purple nutsedge shoot regrowth to greater extent than foliar applications. These data indicate root absorption is required for acceptable sedge control with sulfosulfuron.

Soil- and soil plus foliar–applied trifloxysulfuron provided ≥ 98% shoot number and shoot weight reduction whereas foliar applications provided less reduction (< 50%) (Table 2). Soil- and soil plus foliar–applied trifloxysulfuron also provided greater root weight reduction than did foliar applications. Although soil- and soil plus foliar–applied trifloxysulfuron reduced root weight 86%, harvested roots were partially decayed and were not healthy, indicating root weight may have been overestimated. Within this research, foliar applications did not provide similar reduction as soil or soil plus foliar applications. McElroy et al. (2003, 2004) reported soil- and soil plus foliar–applied trifloxysulfuron reduced purple nutsedge, yellow nutsedge, and green kyllinga growth greater than foliar-applied trifloxysulfuron. Further, McElroy et al. (2003) reported soil-applied trifloxysulfuron reduced yellow and purple nutsedge shoot number greater than foliar and soil plus foliar applications 60 DAT. Previous research has reported soil plus foliar applications of another SU herbicide, halosulfuron, reduced yellow nutsedge shoot growth greater than foliar-only applications (Vencill et al. 1995). Wilcut (1998) reported soil plus foliar–applied pyrithiobac, another ALS-inhibiting herbicide, reduced purple and yellow nutsedge shoot number greater than soil-only or foliar-only applications. ALS-inhibiting herbicides are readily absorbed by roots and foliage and are xylem- and phloem-mobile to the site of action in meristematic regions (Senseman 2007). This indicates acceptable control with ALS-inhibiting herbicides may not be as dependent on specific exposure compared to an herbicide that is not phloem-mobile such as sulfentrazone. Further, in field applications, the amount of potentially available herbicide for root absorption may be dictated by the plant canopy, with soil-applied herbicides having greater herbicide available for root absorption because of the lack of foliar interception. These data indicate evaluated soil-applied ALS-inhibiting herbicides are equally effective as soil plus foliar applications.

Pooled across herbicides, soil and foliar applications provided similar yellow nutsedge, purple nutsedge, and false green kyllinga shoot number and shoot weight reduction 60 DAT (Table 3). Soil applications provided ≥ 87% and ≥ 93% shoot number and shoot weight reduction, respectively, relative to the nontreated, whereas foliar applications reduced shoot number and shoot weight ≤ 37%. Soil applications reduced root weight 76 to 91% whereas foliar applications reduced root weight ≤ 43%, regardless of species. Soil plus foliar–applied herbicides reduced yellow nutsedge and false green kyllinga shoot number and shoot weight ≥ 95% 60 DAT whereas purple nutsedge shoot number and shoot weight were reduced less (65 and 85%, respectively). Soil plus foliar applications provided greater root weight reduction for false green kyllinga than for yellow and purple nutsedge. Greater herbicide concentrations were likely present in the soil and soil plus foliar applications compared to foliar-alone because some of the applied herbicide would be removed with the activated charcoal in the foliar-alone treatments. McElroy et al. (2003) reported



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Table 3. Influence of herbicide placement and species on shoot number, shoot weight, and root weight reduction averaged over herbicides in a greenhouse trial 60 DAT.[a,b]

| Species | Shoot number reduction[c] | | | Shoot weight reduction[d] | | | Root weight reduction[e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil | Foliar | Soil + foliar | Soil | Foliar | Soil + foliar | Soil | Foliar | Soil + foliar |
| | % | | | | | | | | |
| Yellow nutsedge | 87 | 10 | 95 | 93 | 26 | 99 | 76 | 43 | 76 |
| Purple nutsedge | 94 | 21 | 65 | 95 | 37 | 85 | 87 | 43 | 77 |
| False green kyllinga | 97 | 27 | 97 | 99 | 21 | 98 | 91 | 26 | 92 |
| $LSD_{0.05}$ | NS | NS | 12 | NS | NS | 8 | 7 | NS | 10 |

[a] Abbreviations: DAT, days after treatment.

[b] Evaluated herbicides and application rate: sulfentrazone (336 g $ha^{-1}$), sulfosulfuron (53 g $ha^{-1}$), trifloxysulfuron (22 g $ha^{-1}$).

[c] Percentage of shoot number reduction, relative to the nontreated.

[d] Percentage of shoot weight reduction, relative to the nontreated.

[e] Percentage of root weight reduction, relative to the nontreated.

foliar- and soil plus foliar–applied trifloxysulfuron, imazaquin, MSMA, and imazaquin plus MSMA provided greater yellow nutsedge shoot number reduction compared to soil applications, whereas soil and soil plus foliar applications provided greater purple nutsedge shoot number reduction compared to foliar applications. These data and previous research indicate the effect of herbicide placement is likely dependent on species and herbicide.

Based on evaluated parameters, yellow nutsedge and false green kyllinga are more susceptible to sulfentrazone than is purple nutsedge. Further, purple nutsedge and false green kyllinga are more susceptible to sulfosulfuron than is yellow nutsedge; evaluated species responded similarly to trifloxysulfuron. Soil-applied sulfentrazone, sulfosulfuron, and trifloxysulfuron provided the highest level of control, indicating herbicide–soil contact is imperative for optimum sedge control. In most cases, soil plus foliar applications provided growth reduction comparable to soil applications, whereas foliar applications provided less growth reduction. Sulfentrazone, sulfosulfuron, and trifloxysulfuron are shoot- and root-absorbed. Unlike sulfosulfuron and trifloxysulfuron, sulfentrazone is not phloem-mobile, possibly compromising perennial sedge control if soil contact is not ensured (Senseman 2007). Future research should evaluate techniques that encourage herbicide–soil contact, possibly including light irrigation after application or application when minimal foliage is present such as immediately after mowing.

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