Chapter II

Response of Potato (*Solanum tuberosum*) and Selected Weeds to Sulfentrazone

Abstract: Field experiments were conducted in 2000 and 2001 near Painter, VA to evaluate the potential of sulfentrazone for use in potato. Sulfentrazone was applied at 0.11, 0.14, 0.21, and 0.28 kg ai/ha preemergence (PRE) alone or in combination with metolachlor or metribuzin, or at potato emergence (AT EMERG) to simulate a delayed PRE application where the herbicide would contact potato foliage. Potato injury from sulfentrazone PRE at rates up to 0.21 kg/ha was generally similar to injury from metribuzin, metolachlor, or metribuzin plus metolachlor PRE. However, AT EMERG applications resulted in excessive injury that ranged from 60 to 86%. AT EMERG applications also caused decreased potato height and alterations in potato flowering patterns. Sulfentrazone at either application timing controlled common lambsquarters at least 98% even at the lowest rates and was more effective than metribuzin or metolachlor alone. Higher rates of sulfentrazone (0.28 kg/ha) also controlled goosegrass and large crabgrass. However, sulfentrazone at 0.28 kg/ha controlled common ragweed only 58%. Total yield and grade from sulfentrazone PRE applications was similar to potato treated with metribuzin, metolachlor, or metribuzin plus metolachlor in both years. Potato injury from AT EMERG applications of sulfentrazone plus metolachlor decreased total potato yield and caused changes in grade distribution of B-size, small A-size, and extra large potato in 2000.
Nomenclature: metolachlor; metribuzin; sulfentrazone; common lambsquarters, *Chenopodium album* L. #[1] CHEAL; common ragweed, *Ambrosia artemisiifolia* L. #

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[1]Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

AMBEL; goosegrass, *Eleusine indica* (L.) Gaertn. # ELEIN; large crabgrass, *Digitaria sanguinalis* (L.) Scop. # DIGSA; potato, *Solanum tuberosum* L., 'Superior'.

Additional Index Words: degree-days, potato flowering, potato injury, weed control, potato yield and grade, rainfall, sulfentrazone.

Abbreviations: AT EMERG, at-emergence; PRE, preemergence; WAP, weeks after planting; WAT, weeks after treatment.

INTRODUCTION

Potato is an economically important crop in many areas of the Eastern United States. Over 2000 ha of potato are grown in Virginia (Manheimer 2000), primarily in the Eastern Shore region. Effective weed management programs require the integration of preplant tillage, cultivation and hilling, and preemergence (PRE) and/or postemergence (POST) herbicides (Sieczka and Creighton 1984; Lanfranconi et al. 1992).

Although herbicides have become a major component of potato weed management programs, few herbicides are registered for use in potato. Linuron and metolachlor are often used PRE in various rate combinations for control of certain grasses and small-seeded broadleaf weeds. Metribuzin may be used PRE or POST for control of annual broadleaf weeds but is limited by potato varietal sensitivity, particularly with POST applications (Kee and Wooten 1994). In addition, heavy reliance on metribuzin in potato has resulted in shifts to weed species that are more tolerant to metribuzin, as well as emergence of triazine-resistant biotypes of species such as common lambsquarters and redroot pigweed (*Amaranthus retroflexus* L.) (Eberlein et al. 1994). Rimsulfuron is also registered for POST applications in potato, but may be ineffective on species such as common ragweed and common lambsquarters when used under dry conditions (Ackley et al. 1996). Although these herbicides are generally effective on several annual grasses and broadleaf weeds, none control all weed species that commonly occur in potato production. In addition, cultivation-intensive management practices commonly used in potato as well as the need for additional weed scouting when using POST herbicides have resulted in grower preference towards PRE herbicides in Virginia potato production (Bailey et al. 2001; H. P. Wilson, personal communication).

Sulfentrazone is a member of the phenyl triazolinone herbicide group (Theodoridis et al. 1992). Herbicides in this group function through inhibition of protoporphyrinogen oxidase (protox) in plants, a key intermediate in both heme and chlorophyll biosynthesis (Jacobs and Jacobs 1987). Unlike other members of this herbicide group such as the diphenyl ethers, sulfentrazone offers excellent preemergence activity (Dayan et al. 1996; Vidrine et al. 1994). Sulfentrazone is currently registered for weed control in soybean as a prepackaged mixture with chlorimuron[2] and in tobacco as a single entity product[3] (Anonymous 2001). In previous research, sulfentrazone applied preplant incorporated or preemergence controlled several monocotyledonous and dicotyledonous weed species (Ohmes et al. 1998; Oliver et al. 1995; Vidrine et al. 1996) that often occur in potato production. Currently, there are no known weed species resistant to protox-inhibiting herbicides (Duke et al. 1996); therefore, these herbicides could have an important role in future weed management programs.

Although much research supports soybean and tobacco tolerance to sulfentrazone and its performance in these crops (Fisher et al. 2001; Breeden et al. 1999; Oliver et al. 1995; Vidrine et al. 1996), little is known about the tolerance of vegetable crops such as potato to sulfentrazone. Therefore,

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[2]Canopy XL herbicide, E. I. du Pont de Nemours and Co. Agricultural Enterprise, Walker’s Mill, Banley Mill Plaza, Wilmington, DE 19898.

[3]Spartan herbicide, FMC Corporation, Agricultural Chemical Group, 1735 Market Street, Philadelphia, PA 19103.

the objectives of this research were (1) to investigate potato tolerance to sulfentrazone and (2) to evaluate sulfentrazone weed control efficacy in potato weed management programs.

MATERIALS AND METHODS

Field studies were conducted in 2000 and 2001 at the Eastern Shore Agricultural Research and Extension Center near Painter, VA. Soil was a Bojac sandy loam (mixed, thermic Typic Hapludult) with pH 6.2 and <1% organic matter. The seedbed was prepared by moldboard plowing and tandem disk harrowing twice. Superior, a short-seasoned white table stock cultivar, seed tubers were cut into 40-g seed pieces with a commercial seed cutter and planted on March 7, 2000 and March 20, 2001. Seed pieces were planted with a commercial two-row potato planter that formed a 10- to 12-cm ridge over the row during planting. Fertilizer was applied as a band application at planting according to Virginia Polytechnic Institute and State University Extension recommendations (Alexander et al. 2000). Irrigation was applied twice each year (2.5 cm per irrigation) during tuber sizing to supplement rainfall. Row spacing was 0.9 m and seed pieces were spaced 0.3 m apart in the row. Plots consisted of two rows with a plot length of 9.1 m. A buffer of a non-treated row between each set of treated rows was also established. The experimental area was cultivated between rows with a shank-type cultivator[4] and the tops of ridges were cultivated with a flexible-tine cultivator[5] 3 to 4 wk after planting (WAP). This initial cultivation is routine prior to potato emergence and is referred to as "drag-off". All herbicide mixtures were applied following "drag-off" with a propane-pressurized backpack sprayer calibrated to deliver 195 L/ha at

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[4]Dearborn Model 13-1, manufactured by Pittsburgh Co., Coraopolis, PA 42003.

[5]Ferguson No. 33-F Tractor Weeder, manufactured by Ferguson Manufacturing Co., Inc. Suffolk, VA 23434.

207 kPa through flat fan spray tips[6]. Treated plot spray width was 1.8 m. PRE treatments were applied on April 6, 2000 and April 20, 2001 before potato or weed emergence. PRE treatments included sulfentrazone (0.11, 0.14, 0.21, or 0.28 kg ai/ha), metribuzin (0.43 kg ai/ha), and metolachlor (1.12 kg ai/ha), as well as combinations consisting of metribuzin (0.43 kg/ha) plus metolachlor (1.12 kg/ha) (local standard), sulfentrazone (0.21 kg/ha) plus metribuzin (0.28 kg/ha), and sulfentrazone (0.14 kg/ha) plus metolachlor (1.12 kg/ha). Additional treatments were applied at potato emergence (AT EMERG) to contact potato foliage to simulate a delayed PRE application that is common in the area due to wet conditions that often occur in the early spring. AT EMERG treatments were applied on April 11, 2000 and April 24, 2001 when potato were 0 to 5 cm in height. Herbicides applied AT EMERG included sulfentrazone (0.21 kg/ha) alone and sulfentrazone (0.14 kg/ha) plus metolachlor (1.12 kg/ha).

Visual estimates of percent crop injury and weed control were determined using a 0 to 100% scale, where 0 = no injury or control and 100 = complete crop death or complete weed control (Frans et al. 1986). Visual estimates of plant stunting and chlorosis were determined approximately 2 wk after treatment (WAT) with PRE herbicides and 1.5 WAT with AT EMERG herbicides. Plant heights and canopy widths were recorded for six randomly selected plants within each plot 4 to 6 WAT with PRE herbicides. To quantify herbicide effects on potato flower emergence, fifty potato plants from each plot were evaluated for flower emergence at 4 to 6 WAT with PRE herbicides. Weed control estimates were collected approximately 9 WAT with PRE herbicides. Potato was harvested with a commercial potato harvester July 5, 2000, and July 3, 2001. Following harvest, potato tubers were graded according to the United States Department of Agriculture Standards (Anonymous 1991), into culls (tubers less than 38 mm), B-

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[6]Teejet 8003 flat fan spray tips, Spraying Systems Co., North Ave. Wheaton, IL 60188.

size (38 to 48 mm), A-size (small A: greater than 48 mm but less than 76 mm, large A: 76 to 102 mm), and extra large (greater than 102 mm in diameter) using a commercial potato grader.

Environmental conditions such as air temperature, soil temperature, and rainfall at and following PRE and AT EMERG applications each year are listed in Table 1. Cumulative rainfall during the 30-d period following PRE and AT EMERG applications was compared to the 60-yr mean for that period at the experiment site. Heat unit accumulation during the 30-d period following PRE and AT EMERG applications was also calculated based on the formula previously used by Arazi et al. (1993):

$$\text{Degree days} = \{[\text{max. temp. (C)} + \text{min. temp. (C)}]/2\} - \text{base temp. (C)}$$

Base temperature used was 12.2 C, the optimum temperature for flower and tuber initiation (Arazi et al. 1993; Peet 2002).

The experimental design in both years was a randomized complete block with three replications. All data were subjected to analysis of variance (ANOVA) and means were separated using Fisher's protected LSD ($\alpha = 0.05$). If ANOVA residual plot examination indicated nonhomogeneous variance among the data, arcsine square root transformation was used to maintain homogeneity of variance. ANOVA and mean separation were then conducted on transformed data, but untransformed data are presented for clarity. Visual estimates of percent injury and percent weed control were arcsine square root transformed in order to maintain homogeneity of variance. Nontransformed data were used for plant height, canopy diameter, percent flowering, total potato yield, and all grades of tuber yield. In addition, regression analysis was performed to determine if data parameters responded linearly to increasing rates of sulfentrazone applied PRE alone.

RESULTS AND DISCUSSION

Environmental conditions at and following PRE and AT EMERG applications each year are listed in Table 2.1. The soil pH in the experimental area was 6.2 in both years, which is comparable to the dissociation constant (pKa) of sulfentrazone (6.56), allowing sulfentrazone to exist in both neutral and anionic forms (FMC Corp. 1993; Grey et al. 1997). At this soil pH and with low soil organic matter content, sulfentrazone should be adequately soluble in the soil solution to perform well at lower use rates (Guscar et al. 2002). Although air temperature, soil temperature, and rainfall during the 7-d period after PRE applications were generally similar between 2000 and 2001, differences in environmental conditions were noted between years at the time of and just after AT EMERG applications. Differences in rainfall 1 d after AT EMERG applications were noted between years, with 1.2 cm of rainfall occurring in 2001 and none in 2000. Cooler air temperatures were noted at the time of AT EMERG application in 2000 (14.4 C) compared to 2001 (22.8 C).

In the 30-d period after PRE and AT EMERG applications in 2001, 175% and 61% more heat units were accumulated following PRE and AT EMERG applications, respectively, than in 2000. Dryer conditions occurred in 2001, with cumulative rainfall being 0.2 cm below the 60-yr mean for this period. Rainfall during the 30-d period following PRE and AT EMERG applications in 2000 was 2 cm above the 60-yr mean.

Potato response. Significant year by treatment interactions occurred for potato injury; therefore, potato injury is reported separately by year. Potato injury symptoms from PRE applications consisted primarily of plant stunting. Potato injury from sulfentrazone PRE at 0.11 or 0.14 kg/ha was between 5 and 8% at 2 WAT in 2000 and was generally similar to injury observed from PRE applications of metribuzin alone, metolachlor alone, or metribuzin plus metolachlor (Table 2.2). However, as rates of sulfentrazone alone increased to 0.21 and 0.28 kg/ha and with these sulfentrazone rates in combination with metribuzin or metolachlor, potato injury increased to 17 to 33%. Potato injury was highest from AT EMERG applications of sulfentrazone alone or in combination with metolachlor where herbicides were allowed to contact potato foliage. Injury symptoms from AT EMERG applications were similar to typical injury from other photobleaching herbicides (Johnson et al. 1978) and consisted of bronzing of foliage with achlorophyllous veins and some necrosis. Similar injury symptoms from postemergence applications of sulfentrazone have been noted by other researchers (Dayan et al. 1996). Potato injury from sulfentrazone AT EMERG was 72% at 1.5 WAT and increased to 86% with the addition of metolachlor.

In 2001, injury from sulfentrazone PRE alone at 0.11 to 0.21 kg/ha and these rates in combination with metolachlor or metribuzin ranged from 3 to 12% at 2 WAT and was similar to injury from metribuzin or metribuzin plus metolachlor PRE and generally less than injury from metolachlor alone (Table 2.2). Injury from sulfentrazone PRE alone at 0.28 kg/ha was 21% and similar to injury from metolachlor PRE alone. As in 2000, potato injury was greatest from AT EMERG applications. Injury from AT EMERG applications of sulfentrazone alone or in combination with metolachlor ranged from 60 to 66% at 1.5 WAT. In both years, linear regression analysis indicated that potato injury increased linearly with increasing rate of sulfentrazone PRE alone. Injury from PRE and AT EMERG applications of sulfentrazone was generally more in 2000 compared to 2001, possibly due to cooler and wetter conditions following AT EMERG applications in 2000 (Table 2.1). Swantek et al. (1998) noted that cooler conditions and excessive rainfall following application enhanced sulfentrazone injury to soybean cultivars that were more sensitive to this herbicide.

Potato height and flowering. Significant year by treatment interactions occurred for potato height and flowering; therefore, data were presented separately by year. In 2000, herbicide treatment or application timing did not affect average potato height at 4 to 6 WAT (data not presented). Average height of potato receiving PRE applications in 2001 ranged from 40 to 42 cm and was similar for all PRE herbicide treatments (Table 2.3). AT EMERG applications, however, resulted in a reduction in potato height of approximately 15%. Although injury from AT EMERG applications was extensive in both years and resulted in a reduction in plant height in 2001, no significant reductions in canopy width occurred from any treatment at 4 to 6 WAT in either year (data not presented).

Alterations in potato flowering patterns due to AT EMERG applications were observed in both years. In 2000, AT EMERG applications increased potato flowering (Table 2.3). Estimates of the percentage of plants that were flowering were no more than 4% in potato that received any PRE herbicide application. In potato that received AT EMERG applications, 40% flowering was noted in plots that received sulfentrazone alone and 53% flowering occurred in plots that received sulfentrazone plus metolachlor. Contrasting flowering patterns were seen in 2001, where AT EMERG applications resulted in a reduction in flowering at 4 to 6 WAT. Flowering of potato that received any PRE application generally ranged from 52 to 72%, while flowering of potato that received AT EMERG applications was only 14 to 25%. Differences in air temperature between years at the time of AT EMERG applications corresponded with differences in injury between years and could have also influenced differences in flowering patterns. Since flower and tuber initiation are dependent on temperature (Arazi et al. 1993; Peet 2002), differences between years in heat unit accumulation during the 30-d period following applications could also explain differences in flowering patterns between 2000 and 2001.

Weed control. Treatment by year interactions did not occur in weed control data; therefore, data for control of all weed species were pooled over years.

Common lambsquarters control. Common lambsquarters control at 9 WAT was 98 to 99% with sulfentrazone alone at all application rates (Table 2.4). All sulfentrazone-containing treatments controlled common lambsquarters at least 98% regardless of application timing. Sulfentrazone was more effective in controlling common lambsquarters than metolachlor or metribuzin alone. Other researchers have also shown excellent control of common lambsquarters with sulfentrazone (Bruff et al. 1992; Hancock 1995; Oliver et al. 1995).

Common ragweed control. Sulfentrazone was less effective in controlling common ragweed. Other research has also indicated that sulfentrazone does not effectively control common ragweed (Anonymous 2001). Common ragweed control from sulfentrazone PRE alone at 0.11 or 0.14 kg/ha was no more than 29% and increased to only 48% with 0.21 kg/ha (Table 2.4). Although no herbicide treatment controlled common ragweed more than 71%, sulfentrazone PRE at 0.28 kg/ha alone controlled this species 58% and was similar to control from metribuzin alone or metribuzin plus metolachlor. Potato growers with heavy infestations of common ragweed typically apply linuron PRE and/or metribuzin plus rimsulfuron POST for control (Ackley et al. 1996; Bailey et al. 2001; H. P. Wilson, personal communication). Although common ragweed control from sulfentrazone PRE was no more than 58% with any application rate, linear regression analysis indicated that control increased linearly with increasing application rate.

Annual grass control. Predominant annual grass species present in the experimental area both years were large crabgrass and goosegrass. Sulfentrazone PRE alone at 0.11 to 0.21 kg/ha controlled these annual grasses no more than 47% (Table 2.4). However, sulfentrazone PRE alone at 0.28 kg/ha controlled annual grasses 76% and this control was similar to control from all metolachlor-containing treatments. Other research has indicated adequate control of several grass species from sulfentrazone at higher application rates (Hancock 1995). Similar to common ragweed control data, linear regression analysis indicated that increasing rates of sulfentrazone PRE alone correlated to linear increases in annual grass control.

Potato yield and grade. Treatment by year interactions for potato yield and grade did not allow pooling of data over years. Total potato yield in 2000 ranged from 19.7 to 27.9 kg/ha x 10^3 (data not presented). Despite significant early-season injury with higher rates of sulfentrazone PRE, injury diminished to more acceptable levels by mid-season and caused no adverse effects on total potato yield compared to the weed-free check. Potato treated with sulfentrazone alone AT EMERG produced total yields (24 kg/ha x 10^3) that were similar to those from potato that received any PRE application. However, significant reductions in total yield were seen from potato treated with sulfentrazone plus metolachlor AT EMERG (19.7 kg/ha x 10^3) (data not presented).

In addition to reductions in total yield from at least one AT EMERG application, differences in potato grade distribution were also noted from AT EMERG applications in 2000. Amounts of B-size and small A-size tubers were reduced in potato treated with AT EMERG applications (particularly with sulfentrazone plus metolachlor AT EMERG) compared with potato treated with most PRE applications (Table 2.5). Conversely, the amount of extra large potato was increased when AT EMERG applications were made. Potato that received either AT EMERG treatment produced at least 150% more extra large tubers than those treated with PRE applications.

Total potato yield in 2001 was generally higher than in 2000, ranging from 34.5 to 42.5 kg/ha x 10^3 (data not presented). Total potato yield and grade distribution were not affected by herbicide treatment or application timing. No significant linear effect of increasing sulfentrazone rate was noted for total yield or any grade in 2000 or 2001.

According to these data, sulfentrazone has potential as a PRE herbicide for weed management in potato. If sulfentrazone is allowed to contact potato foliage, however, injury is anticipated. Sulfentrazone PRE at rates as low as 0.11 kg/ha controlled common lambsquarters as well as or better than currently-registered herbicides and did not adversely impact potato yield or grade at sulfentrazone rates as high as 0.28 kg/ha. Large crabgrass and goosegrass were also effectively controlled at application rates of 0.28 kg/ha. Other research (Bailey et al. 2002; Hancock 1995; Oliver et al. 1995; Vidrine et al. 1996; Wehtje et al. 1997) has also shown that sulfentrazone effectively controls other weed species such as pigweed (*Amaranthus* spp.), nutsedge (*Cyperus* spp.), and morningglory (*Ipomoea* spp.) that can be problematic in potato production. In addition, sulfentrazone may be useful in triazine resistance management programs for potato.

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Table 2.1. Environmental conditions at and following preemergence and at-emergence applications in 2000 and 2001.

Year	Application	Application date	Air Temp (C)	Soil Temp (C)	Rainfall after application 0-1 d	2-7 d	8-14 d	15-30 d	Rainfall deviation[a]	Heat units[b]
					cm					dd
2000	PRE[c]	April 6	12.2	10.0	0	2.1	4.7	3.1	+ 2	107.5
2000	AT EMERG	April 11	14.4	12.2	0	4.6	2.7	0.9	+ 2	184.0
2001	PRE	April 20	12.5	10.6	0	1.2	0	1.4	- 0.2	295.5
2001	AT EMERG	April 24	22.8	15.6	1.2	0	0	4.3	- 0.2	295.5

[a]Rainfall deviation from 60-yr mean for the 30-d period following PRE and AT EMERG applications.

[b]Heat unit accumulation during the 30 d period following PRE and AT EMERG applications, presented as degree-days (dd). Heat unit calculation was: {[max. temp. (C) + min. temp. (C)]/2} – base temp. (C), with 12.2 C used as base temperature.

[c]Abbreviations: PRE = preemergence; AT EMERG = at-emergence; dd = degree-days.

Table 2.2. Potato injury from sulfentrazone and other herbicides in 2000 and 2001[abc].

Herbicides	Application timing[a]	Application rate	Potato injury[bc] 2000	Potato injury[bc] 2001
		kg/ha	%	%
Sulfentrazone	PRE	0.11	5 g	5 c
Sulfentrazone	PRE	0.14	8 efg	3 c
Sulfentrazone	PRE	0.21	17 de	12 bc
Sulfentrazone	PRE	0.28	33 c	21 b
Metribuzin + metolachlor	PRE	0.43 + 1.12	12 defg	5 c
Sulfentrazone + metribuzin	PRE	0.21 + 0.28	24 cd	11 bc
Sulfentrazone + metolachlor	PRE	0.14 + 1.12	18 de	7 bc
Metribuzin	PRE	0.43	7 fg	15 bc
Metolachlor	PRE	1.12	15 def	22 b
Sulfentrazone	AT EMERG	0.21	72 b	60 a
Sulfentrazone + metolachlor	AT EMERG	0.14 + 1.12	86 a	66 a
Sulfentrazone linear effect[d]			**	*

[a]Abbreviations: PRE = preemergence; AT EMERG = at-emergence.

[b]Means followed by the same letter do not differ according to Fisher's protected LSD at P = 0.05.

[c]Potato injury evaluated 2 wk after treatment with preemergence applications and 1.5 wk after treatment with at-emergence applications.

[d]Regression analysis performed to determine if data parameters respond linearly to increasing rates of sulfentrazone applied PRE alone at 0.11, 0.14, 0.21, and 0.28 kg/ha. Asterisks denote significance at P = 0.10 (*), P = 0.05 (**), or P = 0.0001 (***).

Table 2.3. Average potato plant height[a] in 2001 and average percent flowering[b] in 2000 and 2001 from sulfentrazone and other herbicides.

Herbicides	Application timing[c]	Application rate	Average potato height[de]	Potato flowering[e] 2000	Potato flowering[e] 2001
		kg/ha	cm	%	%
Sulfentrazone	PRE	0.11	41 a	4 c	61 abc
Sulfentrazone	PRE	0.14	41 a	3 c	60 abc
Sulfentrazone	PRE	0.21	42 a	2 c	60 abc
Sulfentrazone	PRE	0.28	41 a	4 c	72 a
Metribuzin + metolachlor	PRE	0.43 + 1.12	42 a	1 c	69 ab
Sulfentrazone + metribuzin	PRE	0.21 + 0.28	42 a	1 c	71 a
Sulfentrazone + metolachlor	PRE	0.14 + 1.12	40 a	3 c	53 bc
Metribuzin	PRE	0.43	41 a	1 c	65 abc
Metolachlor	PRE	1.12	42 a	2 c	52 c
Sulfentrazone	AT EMERG	0.21	35 b	40 b	25 d
Sulfentrazone + metolachlor	AT EMERG	0.14 + 1.12	35 b	53 a	14 d
Weedy check	-	-	42 a	0 c	62 abc
Weed-free check	-	-	42 a	1 c	72 a
Sulfentrazone linear effect[f]			NS	NS	NS

[a]Potato plant height based on mean of six subsamples per plot.

[b]Potato flowering data based on the number of flowering plants per 100 plants in each plot.

[c]Abbreviations: PRE = preemergence; AT EMERG = at-emergence.

[d]Means followed by the same letter do not differ according to Fisher's protected LSD at $P = 0.05$.

[e]Potato plant height and percent flowering measured 4 to 6 wk after PRE treatment in both years.

[f]Regression analysis performed to determine if data parameters respond linearly to increasing rates of sulfentrazone applied PRE alone at 0.11, 0.14, 0.21, and 0.28 kg/ha. Asterisks denote significance at $P = 0.10$ (*), $P = 0.05$ (**), or $P = 0.0001$ (***).

Table 2.4. Control of common lambsquarters, common ragweed, and annual grasses from sulfentrazone and other herbicides[ab].

Herbicides	Application timing[c]	Application rate	Weed control[de]		
			CHEAL	AMBEL	GGGGR
		kg/ha	%		
Sulfentrazone	PRE	0.11	98 a	23 e	34 e
Sulfentrazone	PRE	0.14	98 a	29 e	44 de
Sulfentrazone	PRE	0.21	99 a	48 cd	47 de
Sulfentrazone	PRE	0.28	99 a	58 abc	76 abc
Metribuzin + metolachlor	PRE	0.43 + 1.12	86 ab	71 a	91 ab
Sulfentrazone + metribuzin	PRE	0.21 + 0.28	99 a	59 abc	80 abc
Sulfentrazone + metolachlor	PRE	0.14 + 1.12	99 a	59 abc	92 a
Metribuzin	PRE	0.43	72 bc	69 ab	31 e
Metolachlor	PRE	1.12	60 c	34 de	91 ab
Sulfentrazone	AT EMERG	0.21	98 a	46 cd	65 cd
Sulfentrazone + metolachlor	AT EMERG	0.14 + 1.12	99 a	52 bc	70 bcd
Sulfentrazone linear effect[f]			NS	***	***

[a]Control data for each species pooled over years.

[b]Means within a column followed by the same letter do not differ according to Fisher's protected LSD at P = 0.05.

[c]Abbreviations: PRE = preemergence; AT EMERG = at-emergence.

[d]CHEAL = common lambsquarters (*Chenopodium album* L.); AMBEL = common ragweed (*Ambrosia artemisiifolia* L.); GGGGR = annual grasses, predominantly large crabgrass [*Digitaria sanguinalis* (L.) Scop.] and goosegrass [*Eleusine indica* (L.) Gaertn.].

[e]Weed control data collected 9 wk after treatment with PRE herbicides.

[f]Regression analysis performed to determine if data parameters respond linearly to increasing rates of sulfentrazone applied PRE alone at 0.11, 0.14, 0.21, and 0.28 kg/ha. Asterisks denote significance at P = 0.10 (*), P = 0.05 (**), or P = 0.0001 (***).

Table 2.5. Potato grade and yield as influenced by sulfentrazone and other herbicides in 2000[ab].

Herbicides	Application timing[c]	Application rate	Potato grade[d]			
				A-size		
			B-size	small	large	Extra large
		kg/ha	kg/ha x 10^3			
Sulfentrazone	PRE	0.11	7.7 bc	11.2 a	7.0 ab	0 d
Sulfentrazone	PRE	0.14	7.5 bc	11.1 a	6.8 ab	0.3 cd
Sulfentrazone	PRE	0.21	5.7 cd	9.2 ab	8.8 ab	0.4 c
Sulfentrazone	PRE	0.28	6.6 bcd	9.9 ab	5.9 ab	0.1 cd
Metribuzin + metolachlor	PRE	0.43 + 1.12	7.0 bc	10.4 ab	10.4 ab	0.1 cd
Sulfentrazone + metribuzin	PRE	0.21 + 0.28	7.0 bc	9.3 ab	5.2 ab	0.1 cd
Sulfentrazone + metolachlor	PRE	0.14 + 1.12	6.5 bcd	11.5 a	9.7 ab	0.1 cd
Metribuzin	PRE	0.43	8.2 ab	11.5 a	7.8 ab	0 d
Metolachlor	PRE	1.12	8.1 abc	11.2 a	7.3 ab	0 d
Sulfentrazone	AT EMERG	0.21	4.2 d	7.7 bc	11.1 a	1.0 b
Sulfentrazone + metolachlor	AT EMERG	0.14 + 1.12	4.1 d	5.2 c	8.7 ab	1.7 a
Weedy check	-	-	10.4 a	11.2 a	4.4 ab	0 d
Weed-free check	-	-	7.0 bc	10.5 ab	9.8 ab	0.1 cd
Sulfentrazone linear effect[e]			NS	NS	NS	NS

[a]Potato yield and grade data analyzed separately by year. Data presented for year 2000 only due to no significant treatment effect on potato grade or total yield in 2001.

[b]Means followed by the same letter do not differ according to Fisher's protected LSD at P = 0.05.

[c]Abbreviations: PRE = preemergence; AT EMERG = at-emergence.

[d]B-size = 38 to 48 mm, A-size: small A = greater than 48 mm but less than 76 mm, large A = 76 to 102 mm), extra large = greater than 102 mm in diameter. Grading conducted using a commercial potato grader and according to the United States Department of Agriculture Standards.

[e]Regression analysis performed to determine if data parameters respond linearly to increasing rates of sulfentrazone applied PRE alone at 0.11, 0.14, 0.21, and 0.28 kg/ha. Asterisks denote significance at P = 0.10 (*), P = 0.05 (**), or P = 0.0001 (***).