Sulfonylurea Herbicides Reduce Survival and Seed Production of Green and Yellow Foxtails (*Setaria* spp.)[1,2]

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Abstract. Chlorsulfuron or metsulfuron applied POST at 10 g ai ha^{-1} at the four-leaf stage prevented yellow foxtail from forming seed, whereas seed production per pot was 53 to 77% of untreated checks following POST tribenuron or CGA-131036 treatments in greenhouse experiments. Chlorsulfuron applied POST at the two- and four-leaf stage severely reduced total seed production of yellow foxtail primarily by increasing plant mortality, rather than only reducing seed production per plant. Chlorsulfuron at 10 g ha^{-1} applied at the six- and eight-leaf stages decreased total seed production less than at the two earlier stages, by reducing both plant mortality and seed production per surviving plant. Yellow foxtail was much more susceptible than green foxtail to either chlorsulfuron or metsulfuron. **Nomenclature.** CGA-131036, *N*-(6-methoxy-4-methyl-1,3,5-triazin-2-yl-amino-carbonyl)-2-(2-chloroethoxy)-benzenesulfonamide; chlorsulfuron, 2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide; metsulfuron, 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid; tribenuron, 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)methylamino]carbonyl]amino]sulfonyl]benzoic acid; green foxtail, *Setaria viridis* (L.) Beauv. #[4] SETVI; yellow foxtail, *Setaria glauca* (L.) Beauv. # SETLU.

Additional index words: CGA-131036, chlorsulfuron, metsulfuron, tribenuron, *Setaria glauca*, *Setaria viridis*, SETLU, SETVI.

INTRODUCTION

Green and yellow foxtail are troublesome annual grass weeds in spring wheat (*Triticum aestivum* L.) in the northern Great Plains of the USA (7, 9) and Prairie Provinces of Canada (8, 9, 11). Several studies document that certain POST herbicides selectively control foxtails in spring wheat (1, 3, 7, 10, 15). Sulfonylurea herbicides selectively control many broadleaf weeds infesting spring wheat (6) and partially control some grasses, including foxtails (6, 15). In North Dakota, chlorsulfuron controlled mixed stands of green and yellow foxtail infesting spring wheat 60 to 85% (13). In other field studies, chlorsulfuron at 30 g ha^{-1} controlled mixed stands of green and yellow foxtail in spring wheat 59, 78, and 94% when applied at the three- to four-leaf stage.[5] Surviving plants were dwarfed and seedheads formed well below the wheat canopy.

Green and yellow foxtail are prolific seed producers which can form between 5000 and 12 000 seed per plant when growing in sparse stands without competition (8, 17). Substantially less seed is produced in competition with spring wheat, however (8). Thus, weed control likely will reduce future weed infestations by reducing seed produced per unit area. Little is known about either the degree to which herbicides reduce weed seed production or the demographic mechanism for reduced weed seed production, particularly for weed species that are only partially controlled by herbicides.

No published information was found on whether the sulfonylurea herbicides chlorsulfuron, metsulfuron, tribenuron, or CGA-131036 reduced foxtail survival or seed production (6). Also, the demographic mechanism by which sulfonylurea herbicides reduced green and yellow foxtail seed produced per unit area has not been reported (e.g., herbicide effects on seedling mortality

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[2]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Dep. Agric. and does not imply its approval to the exclusion of other products that also may be suitable.

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[4]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

[5]William W. Donald, 1983, 1985, and 1986, unpublished data.

versus seed production of surviving plants). The objectives of this research were to: 1) compare the relative effects of chlorsulfuron, metsulfuron, tribenuron, and CGA-131036 on green and yellow foxtail seedling mortality and seed production; 2) determine whether chlorsulfuron applied to yellow foxtail at various leaf stages reduced total seed produced per pot by differentially reducing plant survival or seed produced per surviving plant, or both; and 3) determine the relative effect of chlorsulfuron on yellow foxtail population biology when applied only to the foliage, both the foliage and soil, or only to the soil.

MATERIALS AND METHODS

General methods. Mature seed of green and yellow foxtail were collected from wheat fields near Fargo, N.D. in late August, 1986. Foxtail seed were air dried and stored in the greenhouse until seed were fully germinable. Forty seed per pot of each species were planted 1 cm deep in a sand and peat-amended potting soil mixture (84% sand, 12% silt, 4% clay, and 8% organic matter, and pH 7.1) in black plastic pots (15-cm diam by 18-cm tall, 3-L vol). Soil was fertilized with 8 g per pot of controlled release fertilizer[6]. Pots were subirrigated initially to avoid seed disturbance and ensure uniform establishment after emergence. Plants were surface watered daily after emergence, and seedlings were thinned to 20 plants per pot before herbicide treatment (= 1132 plant per m^2). In a survey of North Dakota spring wheat fields, green and yellow foxtail density averaged 75 and 24 plants per m^2, respectively, by harvest (7), with maximum densities of 400 and 350 plants per m^2, respectively. Densities at the time of herbicide treatment in spring can be three- to four-fold greater[5], however, and weed stands decrease over the growing season due to natural mortality in spring wheat.

Supplemental fluorescent lighting provided a 14-h photoperiod for greenhouse-grown plants, although natural daylength was longer during May and June (Figure 1). Fluorescent light intensity at the seedling height ranged between 150 and 280 $\mu E\ m^{-2}\ s^{-1}$ measured at night. Daytime air temperatures varied between 27 and 33 C (average of 30 C) and nighttime temperatures ranged from 23 to 25 C (average of 24 C). Relative humidity during the day and night ranged between 45 and 55% during the course of the experiments.

Sulfonylurea herbicides were applied with a moving nozzle sprayer equipped with a flat fan nozzle[7] that traveled at 0.77 km h^{-1} and delivered 120 L ha^{-1} of spray solution at 210 kPa. Seeding was staggered over time so that plants at various leaf stages could be treated on the same day.

Plants surviving treatment were counted 16 to 20 d after treatment, depending upon the experiment, whereas seed weight per pot (g) was determined at maturity, 34 to 39 d after treatment, depending upon the experiment. Plant survival was expressed as a percentage of the number of treated plants present initially (20 plants per pot). To estimate seed number per surviving plant, 200 seed per treatment were weighed and seed produced per surviving plant (SP)[8] was determined by the formula: $SP = (200\ (W/w))/N$ where w = seed weight (g) of 200 seed of either green or yellow foxtail, W was the total seed weight per pot (g), and N was the number of plants surviving treatment. Total seed production (seed produced per pot) was estimated as the product of the number of surviving plants and seed number per surviving plant.

Data were subjected to analysis of variance (ANOVA)[8] using SPSS-PC+ software[9]. Means were separated by Fisher's protected least significant difference (LSD) at $P = 0.05$ with and without arcsine transformation (2). Standard errors are included in the tables to provide readers with additional statistical information (5, 12, 14, 16). Each experiment was repeated.

Sulfonylurea herbicides efficacy on green and yellow foxtail. A completely randomized design was used in a 5 by 2 factorial arrangement with four pots per treatment. Treatments were four herbicides and an untreated check and two foxtail species.

Trials 1 and 2 were planted on Jan. 24 and Mar. 22, 1987, respectively, and lasted about 2 mo (Figure 1). Chlorsulfuron, metsulfuron, CGA-131036[10], and tribenuron were applied to green and yellow foxtail at 10 g ha^{-1} plus nonionic surfactant[11] at 0.2% (v/v) 25 d after planting. Surviving plants were counted 20 d after

[6]Osmocote, (18-6-12 N-P_2O_5-K_2O) from Sierra Chemical Co., 1001 Yosemite Drive, Milpitas, CA 95035.

[7]TeeJet 800067 flat fan nozzle tip, from Spraying Systems Co., Wheaton, IL 60188.

[8]Abbreviations: SP, seed production per surviving plant; ANOVA, analysis of variance.

[9]SPSS/PC+ ver. 4, SPSS Inc., 444 N. Michigan Ave., Chicago, IL 60611.

[10]Amber, from Agric. Div., CIBA-GEIGY Corp., Greensboro, NC 27409.

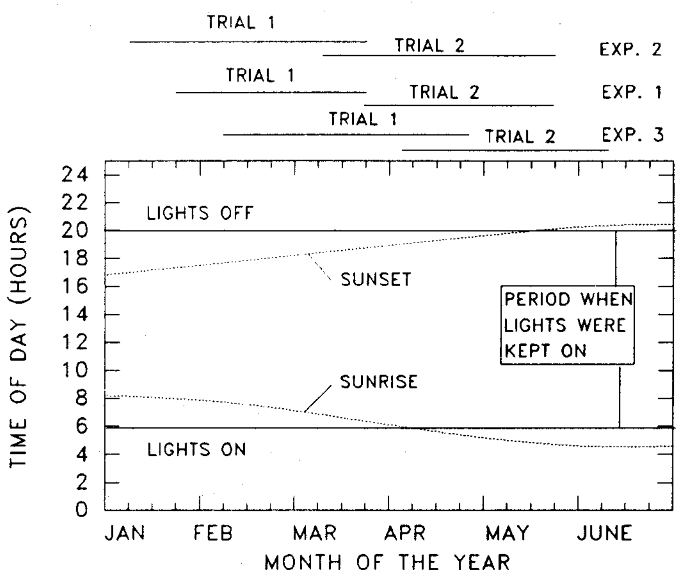

Figure 1. Time of sunrise and sunset during the 24-h day from January to June at Fargo, ND. Times of day that greenhouse fluorescent lighting was turned on and off and the time frame that each trial of the three experiments conducted are indicated.

herbicide treatment. In Trial 1, green and yellow foxtail were harvested when mature, 29 and 34 d after herbicide application, respectively. In Trial 2, both species matured more slowly and were harvested 39 d after herbicide application.

Chlorsulfuron rate and yellow foxtail leaf stage. The treatments consisted of an untreated check and chlorsulfuron at 10 g ha^{-1} plus nonionic surfactant at 0.2% (v/v) applied at the two-, four-, six-, and eight-leaf stages of yellow foxtail in a 2 by 4 factorial arrangement in a completely randomized design with four pots per treatment. Chlorsulfuron was chosen for this research because it reduced foxtail seed production in the field[5].

Trials 1 and 2 were started on Jan. 5 and Mar. 7, 1987, respectively, and lasted approximately 2 mo (Figure 1). Foxtail planting dates were staggered to obtain vegetative plants at various leaf stages at the time of herbicide application, 37 to 44 d after the first foxtail were seeded. Chlorsulfuron plus nonionic surfactant at 0.2% (v/v) was applied on Feb. 18, 1987, in Trial 1 and April 16, 1987, in Trial 2, respectively. Percent plant survival was determined 20 and 19 d after spraying in Trials 1 and 2, respectively. Plants were harvested when seed were mature, resulting in different harvest dates for plants of different ages. Harvesting was conducted from March 14 to 22 in Trial 1 and from May 19 to 26 in Trial 2.

Soil versus shoot applications of chlorsulfuron. This experiment had a completely randomized design with four pots per treatment. Yellow foxtail was treated with chlorsulfuron (0, 10, and 20 g ha^{-1}) plus nonionic surfactant at 0.2% (v/v) using three application methods (shoot only, soil only, and shoot plus soil) in a 3 by 3 factorial arrangement.

Trials 1 and 2 were started on Feb. 8 and April 4, 1987, respectively, and lasted approximately 2 mo (Figure 1). Chlorsulfuron was applied to foxtails at the four-leaf stage, 25 d after planting. Shoot only treatments were applied to foxtails in pots with vermiculite covering the soil surface before herbicide application to prevent soil exposure and root uptake. Vermiculite was removed after the spray had dried on the foliage. Soil only treatments were applied to the soil surface of each pot in 10 ml of solution with a pipette. Enough herbicide without surfactant was applied to equal the spray application rate on a unit area basis Shoot plus soil treatments were broadcast sprayed over the foxtail foliage and the soil surface without vermiculite. Percent plant survival was observed 16 d after herbicide application. Yellow foxtail seed were harvested at maturity on April 15 for Trial 1 and June 10 for Trial 2.

RESULTS AND DISCUSSION

When there were significant two-way interactions between treatment and trial, results are presented by trial. There were several possible reasons for the interactions. Although greenhouse temperature and relative humidity were maintained within specified bounds, Trial 2 of each experiment experienced photoperiods longer than the 14 h provided by supplemental fluorescent lighting for Trial 1 (Figure 1). Natural daylength in North Dakota increases from approximately 8 h in January to 16 h in June. Foxtails matured later in Trial 2 than in Trial 1, probably because of increasing photoperiod and light intensity. Seed production of untreated yellow foxtail reportedly (18) increased as photoperiod increased. Plants were grown to maturity in the greenhouse in 2-mo experiments repeated over 6 mo between January and June. Such long-term plant growth studies

[11]Ortho-X-77 (alkylarylpolyoxyethylene glycol, free fatty acids and isopropanol, 90%), from Chevron Chemical Co., Richmond, CA, now available as Valent X-77 from Valent U.S.A. Corp., 1333 N. California Blvd., Walnut Creek, CA 94596-8025.

Table 1. The effect of four sulfonylurea herbicides at 10 g ai ha^{-1} applied at the four-leaf stage on plant survival and total seed production (per pot) and seed produced per surviving plant of yellow foxtail.

Herbicide	Survival[a]	Seed production[a]	
	%	no. per pot[b]	no. per plant
Untreated check	100	2970 (± 470) a	149 (± 23) a
Chlorsulfuron	8 (± 2) a	0	0
Metsulfuron	6 (± 2) a	0	0
Tribenuron	79 (± 6) b	1790 (± 300) b	108 (± 11) b
CGA-131036	71 (± 6) b	2100 (± 310) b	150 (± 20) a

[a]Means and standard errors in parentheses are presented. Means in a column followed by the same letter were not different at P = 0.05 by the LSD test for the average of two trials. Treatments with either all 0's or all 100's were excluded from the ANOVA and LSD tests.

[b]To calculate the number of seed produced per m^2, divide the seed no. per pot by the pot surface area (0.018 m^2).

are inherently more variable than short-term experiments (4).

Sulfonylurea herbicide and foxtail species. Chlorsulfuron and metsulfuron[12] at 10 g ha^{-1} applied at the four-leaf stage severely reduced yellow foxtail plant survival and prevented seed production of surviving yellow foxtail plants (Table 1). No yellow foxtail plants formed seed and 8% or fewer yellow foxtail plants survived chlorsulfuron or metsulfuron treatment. Both chlorsulfuron and metsulfuron at 10 g ha^{-1} reduced plant survival and seed production of surviving yellow foxtail more than either tribenuron or CGA-131036 when applied at the four-leaf stage.

CGA-131036 and tribenuron reduced survival of yellow foxtail (71 and 79% of the untreated check, respectively) and total seed production (71 and 60% of the untreated check, respectively) similarly (Table 1). However, CGA-131036 reduced total seed production of yellow foxtail largely by decreasing plant survival (71% of the untreated check) without reducing seed produced per surviving plant. In contrast, tribenuron reduced total seed production of yellow foxtail by reducing both plant survival (79% of the untreated check) and seed produced per surviving plant (72% of the untreated check).

Both chlorsulfuron and metsulfuron reduced plant survival and seed production of yellow foxtail (Table 1) much more than that of green foxtail (Table 2). Yellow foxtail also responded more consistently to POST-applied sulfonylurea herbicides than green foxtail (Table 2), allowing trials to be combined for yellow foxtail in this experiment (Table 1). Green foxtail plant survival and seed production were reduced in Trial 1 but not in Trial 2, compared to the untreated check.

Chlorsulfuron rate and foxtail leaf stage. In both trials, chlorsulfuron a 10 g ha^{-1} applied at the two- and four-leaf stage prevented yellow foxtail from forming any seed, whereas plants treated at the six- and eight-leaf stage formed progressively more total seed as leaf stage at treatment increased (Figure 2). Chlorsulfuron-treated yellow foxtail never produced as much total seed as untreated checks at comparable leaf stages.

No yellow foxtail plants survived chlorsulfuron treatment at the two-leaf stage. At the four-leaf stage, 3 to 28% of chlorsulfuron-treated yellow foxtail plants survived herbicide treatment (Figure 3), yet survivors failed to form any seed (Figure 4). At the six-leaf stage, both reduced plant survival (Figure 3) and decreased seed production per surviving plant (Figure 4) contributed to decreases in total seed production of yellow foxtail (Figure 2). Total seed production (Figure 2) was decreased by chlorsulfuron applied at the eight-leaf stage primarily through reduced seed production per surviving plant (Figure 4), rather than increased mortality (Figure 3). Fewer than 20% of yellow foxtail plants

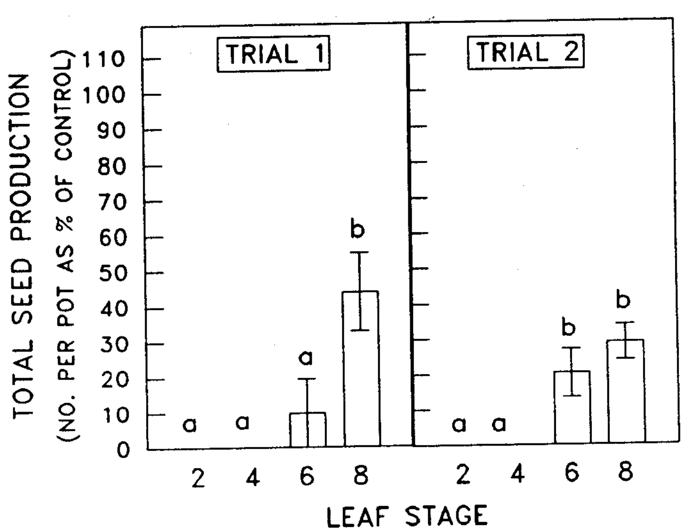

Figure 2. Total seed production of yellow foxtail seed versus leaf stage at the time of POST chlorsulfuron application at 10 g ha^{-1} as a percent of the untreated check at each respective leaf stage. Means ± standard errors are presented. Means followed by the same letter do not differ at P = 0.05 according to the LSD within a trial.

[12]Chlorsulfuron at 10 to 20 g ha^{-1} and metsulfuron at 10 g ha^{-1} were registered by the U.S. Environmental Protection Agency for broadleaf weed control in spring wheat when this experiment was started. Tribenuron and CGA-131036 were experimental herbicides when this research was conducted and were applied at 10 g ha^{-1}, as suggested by their manufacturers.

Table 2. The effect of four sulfonylurea herbicides at 10 g ai ha^{-1} applied at the four-leaf stage on green foxtail survival and total seed production (per pot) and seed produced per surviving plant.

Herbicide	Survival[a]		Seed production[a]			
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
	%		no. per pot[b]		no. per plant	
Untreated check	100 a	100 a	7330 (± 300) a	4930 (± 1490) ns	366 (± 15) a	242 (± 44) ns
Chlorsulfuron	69 (± 4) b	94 (± 2) bc	4380 (± 260) b	5930 (± 360) ns	320 (± 17) a	317 (± 25) ns
Metsulfuron	58 (± 3) c	93 (± 1) c	1320 (± 370) c	4480 (± 450) ns	90 (± 40) b	241 (± 21) ns
Tribenuron	94 (± 4) a	96 (± 2) ab	6460 (± 1740) ab	5810 (± 330) ns	312 (± 38) a	243 (± 25) ns
CGA-131036	100 a	99 (± 1) a	5840 (± 690) ab	4650 (± 370) ns	323 (± 87) a	294 (± 20) ns

[a]Means and standard errors in parentheses are presented. Means in a column followed by the same letter were not different at P = 0.05 by the LSD test. Treatments in columns marked "ns" were not significantly different from one another by the ANOVA.

[b]To calculate the number of seed produced per m^2, divide the seed no. per pot by the pot surface area (0.018 m^2).

treated with chlorsulfuron at the eight-leaf stage were killed (Figure 3).

Seed production per plant for those yellow foxtail plants surviving chlorsulfuron treatment at 10 g ha^{-1} was regressed on percent plant survival for all leaf stages averaged over the two trials (Figure 5). As more plants survived treatment, survivors formed progressively more seed per plant, although seed production per plant never equalled that of untreated checks of comparable age (data not presented). Density-dependent reductions in seed production per plant were not observed. Theoretically, one would have expected that the denser untreated checks would form fewer seed per plant than herbicide-treated survivors if seed production were regulated solely by density dependence. Apparently, herbicide treatment limited seed production more than plant density.

Soil versus shoot effects of chlorsulfuron. Three percent or fewer yellow foxtail plants survived chlorsulfuron at 10 and 20 g ha^{-1} applied at the four-leaf stage to the shoot only or the shoot plus soil (data not shown). Survivors of either type of foliar treatment failed to form any seed.

In contrast, 35 to 50% of yellow foxtail survived soil treatment alone (Table 3). Fewer yellow foxtail plants survived soil treatment alone with chlorsulfuron at 20 g ha^{-1} (14 to 35%) than at 10 g ha^{-1} (46 to 50%). Surviving yellow foxtail also formed fewer total seed per pot than the untreated check following soil treat-

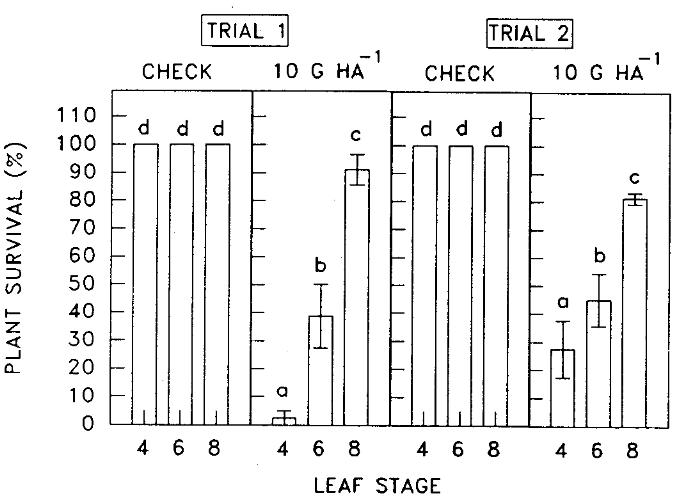

Figure 3. Yellow foxtail plant survival as a percent of the number of plants present initially versus leaf stage at the time of POST chlorsulfuron application at 10 g ha^{-1}. Means ± standard errors are presented. Means followed by the same letter do not differ at P = 0.05 according to the LSD within a trial.

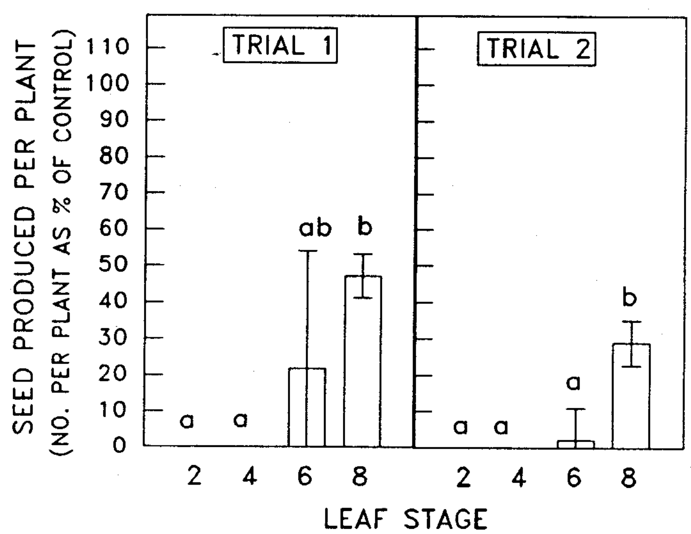

Figure 4. Yellow foxtail seed produced per surviving plant versus leaf stage at the time of POST chlorsulfuron application at 10 g ha^{-1} as a percent of the untreated check at each respective leaf stage. Means ± standard errors are presented. Means followed by the same letter do not differ at P = 0.05 according to the LSD within a trial.

Table 3. The effect of chlorsulfuron rate and soil application alone at the four-leaf stage on survival and total seed production (per pot) and seed produced per surviving plant of yellow foxtail[a].

Treatment		Survival		Seed production			
Method	Rate	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
	g ha^{-1}	%[a]		no. per pot[b]		no. per plant	
Untreated check	0	100 a	100 a	5230 (± 370) a	2670 (± 460) a	261 (± 18) a	131 (± 23) b
Soil	10	50 (± 13) b	46 (± 6) b	1510 (± 230) b	1470 (± 370) b	197 (± 60) ab	170 (± 47) a
	20	35 (± 6) c	14 (± 5) c	1050 (± 250) b	60 (± 30) c	149 (± 18) b	14 (± 8) c

[a]Means and standard errors in parenthesis are presented. Means in a column followed by the same letter were not different at P = 0.05 by the LSD test.
[b]To calculate the number of seed produced per m^2, divide the seed no. per pot by the pot surface area (0.018 m^2).

ment alone. Because the soil potting mixture was high in sand (84%), soil residues of chlorsulfuron were expected to be highly phytotoxic (6). Chlorsulfuron residues in soil may not have effectively killed yellow foxtail after establishment (Table 3) because chlorsulfuron was less toxic to yellow foxtail when absorbed from the soil alone. The availability of chlorsulfuron for plant uptake may have been reduced by adsorption to peat in the potting mixture (6).

Although visual control and shoot dry weight reductions are often measured to determine the toxicity of herbicides to weeds, variables such as plant survival and seed produced per unit area or per surviving plant can provide additional insight into the mechanism of herbicidal control of weed populations. Because seed surviving in the soil seed bank are responsible for year to year persistance of foxtails on farmland (8, 18), quantitative information regarding the effects of herbicides on seed produced by plants surviving treatment may be useful for estimating future foxtail infestations. These greenhouse experiments suggest that POST-applied chlorsulfuron may limit the buildup of yellow foxtail populations on farms by decreasing seed produced per unit area. This research also suggests that if chlorsulfuron or metsulfuron reduce foxtail populations from one year to the next, it may be due to both reduced plant survival and/or subsequent decreased seed produced per surviving plant in the previous year. Whether yellow foxtail seed production was reduced by chlorsulfuron due to increased plant mortality or reduced seed produced per surviving plant depended on the leaf stage when treated. Fewer plants died following treatment at later leaf stages. Chlorsulfuron treatment may favor the buildup of green foxtail over yellow foxtail on farmland infested with both species because chlorsulfuron did not control green foxtail as consistently as yellow foxtail.

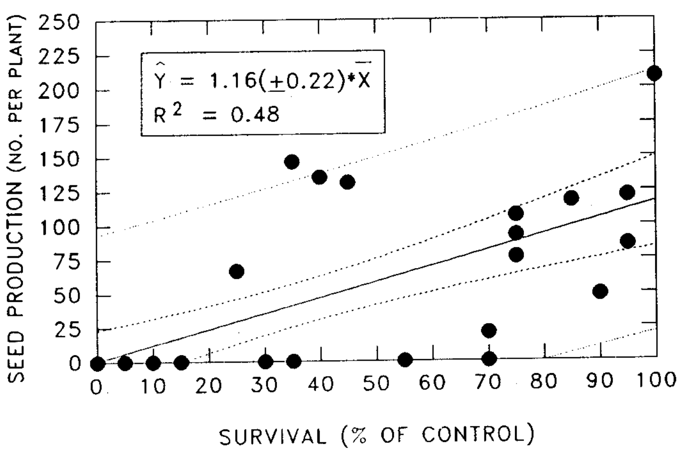

Figure 5. Regression equation for the relationship between yellow foxtail seed produced per plant (Y) surviving treatment with chlorsulfuron at 10 g ha^{-1} applied at various leaf stages and percent survival (X). The 95% confidence interval (– – –) and prediction interval (. . . . .) are present.

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LITERATURE CITED

1. Andersen, R. N. 1976. Response of monocotyledons to HOE 22870 and HOE 23408. Weed Sci. 24:266–269.
2. Ahrens, W. H., D. J. Cox, and G. Budhwar. 1990. Use of the arcsine and square root transformations for subjectively determined percentage data. Weed Sci. 38:452–458.
3. Chow, P.N.P. 1978. Selectivity and site of action in relation to field performance of diclofop. Weed Sci. 26:352–358.
4. Causton, D. R., and J. C. Venus. 1981. The Biometry of Plant Growth. Edward Arnold, London.
5. Day, R. W., and G. P. Quinn. 1989. Comparisons of treatments after an analysis of variance in ecology. Ecol. Monogr. 59:433–463.
6. Donald, W. W. 1990. Sulfonylurea herbicides. p. 423–476 *in* W. W. Donald, ed. Systems of Weed Control in Wheat in North America. Weed Sci. Soc. Am., Champaign, Ill.
7. Donald, W. W., and J. D. Nalewaja. 1990. Northern Great Plains. p. 90–127 *in* W. W. Donald, ed. Systems of Weed Control in Wheat in North America. Weed Sci. Soc. Am., Champaign, Ill.

8. Douglas, B. J., A. G. Thomas, I. N. Morrison, and M. G. Maw. 1985. The biology of Canadian weeds, 70. *Setaria viridis* (L.) Beauv. Can. J. Plant Sci. 65:669–690.
9. Fay, P. K. 1990. A brief overview of the biology and distribution of weeds of wheat. p. 33–50 *in* W. W. Donald, ed. Systems of Weed Control in Wheat in North America. Weed Sci. Soc. Am., Champaign, Ill.
10. Grafstrom, L. D., Jr., and J. D. Nalewaja. 1981. Propanil + MCPA ester for foxtail control in wheat. Proc. North Cent. Weed Control Conf. 36: 49.
11. Hunter, J. H., I. N. Morrison, and D.R.S. Rourke. 1990. The Canadian Prairie Provinces. p. 51–90. *in* W. W. Donald, ed. Systems of Weed Control in Wheat in North America. Weed Sci. Soc. Am., Champaign, Ill.
12. Jones, D., and N. Matloff. 1986. Statistical hypothesis testing in biology: a contradiction in terms. J. Econ. Entomol. 79:1156–1160.
13. Miller, S. D., and J. D. Nalewaja. 1979. DPX-4189 (chlorsulfuron) for weed control in small grains and fallow. Proc. North Cent. Weed Control Conf. 34:37–39.
14. Morse, P. M., and B. K. Thompson. 1981. Presentation of experimental results. Can. J. Plant Sci. 61:799–802.
15. Nalewaja, J. D., and Z. Woznica. 1985. Environment and chlorsulfuron phytotoxicity. Weed Sci. 33:395–399.
16. Perry, J. N. 1986. Multiple-comparison procedures: a dissenting view. J. Econ. Entomol. 79:1149–1155.
17. Santelmann, P. W., J. A. Meade, and R. A. Peters. 1963. Growth and development of yellow foxtail and giant foxtail. Weeds 11:139–149.
18. Steel, M. G., P. B. Cavers, and S. M. Lee. 1983. The biology of Canadian weeds. 59. *Setaria glauca* (L.) Beauv., and *S. verticillata* (L.) Beauv. Can. J. Plant Sci. 63:711–725.