Tolerance of Three Wheatgrass Cultivars to Sulfosulfuron Herbicide

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ABSTRACT

Crested, tall, and pubescent wheatgrasses are cool-season, drought-resistant perennial forages that grow well in semiarid environments and could complement wheat pasture grazing systems of the Texas Rolling Plains. However, wheatgrass stand establishment is difficult due to competing winter grasses. This study evaluated wheatgrass cultivars for tolerance to a sulfonylurea herbicide that may control competing annual grass weeds in wheatgrass stand establishment. Utilizing greenhouse facilities, three rates of sulfosulfuron were applied preemergence, 2 weeks after emergence (2 WAE) at the 2-leaf stage, or 4 WAE at the 3- to 4-leaf stage to individual plants of 'CD II' (crested), 'Jose' (tall), and 'Manska' (pubescent) wheatgrasses. Sensitivity to sulfosulfuron was least for CD II and greatest for Manska. Considering all treatments and timings, Manska and Jose had greater declines in above-ground and below-ground biomass and fewer surviving seedlings than CD II. Wheatgrass cultivars were most sensitive to sulfosulfuron when treated 2 WAE. Plant survival increased when sulfosulfuron application was delayed to 4 WAE, except for Manska where nearly 100% of the plants died regardless of herbicide rate. A rigorous selection program with CD II could possibly lead to the development of a non-genetically engineered, sulfosulfuron-tolerant crested wheatgrass.

KEY WORDS: Cool-Season grasses, Texas Rolling Plains, Winter forages

INTRODUCTION

Wheatgrasses like CD II [crested, *Agropyron cristatum* (L.) Gaertn. x *A. desertorum* (Fisch. ex Link) J. A. Schultes]), Jose [tall, *Thinopyrum ponticum* (Podp.) Barkworth & D. R. Devey], and Manska [pubescent, *T. intermedium* ssp. *barbulatum* (Shur) Barkworth & D. R. Devey] are cool-season, drought-resistant perennial grasses that provide excellent, high-quality forage for cattle and grow well in the semiarid environments of the southern Great Plains in addition to prairies of the western United States and Canada (Asay, 1995). Crested wheatgrass is seeded on approximately 12 million acres (Rogler and Lorenz, 1983). Wheatgrasses complement wheat pastures and bridge the gap in forage availability between initiation of grazing on native rangeland and improved warm-season grass pastures (Redmon and Bidwell, 1997; Reuter et al., 1999).

Crested, tall, and pubescent wheatgrasses are cross-pollinating polyploids (Asay, 1995). CD II is a 10-clone synthetic cultivar (Asay et al., 1997), while Manska is a 116-clone synthetic cultivar (Berdahl et al., 1993). Synthetic cultivars are defined as an advanced generation of a seed mixture of strains, clones, inbreds, or hybrids among them, propagated for a limited number of generations by open-pollination (Poehlman and Sleper, 1995). Therefore, synthetic cultivars can express more variation than standard cultivars to applied stresses because of more heterogeneity within the gene pool. Jose was developed as a non-synthetic cultivar (Anon., 1966).

Wheatgrass is usually planted from mid-September to October to take advantage of fall rains and cooler air temperatures during this period in the southern Great Plains. Establishing a uniform stand of wheatgrass can be difficult due to competition from annual winter grass weeds. Broadleaf weeds can be controlled in established cool-season grasses with 2,4-D (2,4-dichlorophenoxyacetic acid) or picloram (4-amino-3,5,6-trichloropicolinic acid) (Regehr et al., 2001). Control of some winter annual grasses also can be achieved. Whitson et al. (1997) reported at least 95% control of downy brome (*Bromus tectorum* L.) when applying either 1.0 lb ai ac^{-1} oxyfluorfen [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluro-methylbenzene)] plus 0.25 lb ai ac^{-1} metribuzin (4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one) or 0.35 lb ai ac^{-1} metribuzin in the fall to established western (*Pascopyrum smithii* Rydb.), slender [*Elymus trachycaulus* (Link) Gould ex Shinners], or thickspike (*Elymus lanceolatus* Scribn. and Smith) wheatgrasses. Atrazine (6-chloro-N^2-ethyl-N^4-isopropyl-1,3,5-triazine-2,4-diamine) and diuron [N'-(3,4-dichlorophenyl)-N,N-dimethylurea] also exhibited high levels of downy brome control in established stands of crested wheatgrass (Wicks et al., 1965).

Fewer options are available for controlling annual grass weeds in seedling wheatgrass. Weed competition can be decreased by using an integrated weed management approach of a preplant burndown application of paraquat (1,1'-dimethyl-4,4' bipyridinium dichloride) or glyphosate [isopropylamine salt of N-(phosphono-methyl glycine)] prior to seeding wheatgrass in a stale seedbed. However, subsequent weed populations from later emerging weeds can occur while the wheatgrass is establishing, resulting in stand reductions. Peters et al. (1989) reported at least 90% control of a number of summer annual grasses with fenoxaprop {(+)-ethyl 2-[4-[(6-chloro-2-benzoxazolyl)oxy]phenoxy] propanoate)} at 0.2 lb ai ac^{-1} in seedling intermediate wheatgrass. However, control of winter annual grass weeds is more difficult because of similar emergence and development with fall-seeded wheatgrass. Winter annual grass weeds have been documented to be vigorous competitors for water and nutrients with wheatgrass and other cool-season perennial grasses during seedling establishment, thus decreasing the number of surviving plants (Skipper et al., 1996). In the southern Great Plains, winter annual grass competition is primarily comprised of the *Bromus* weed species complex [downy brome, cheat (*Bromus tectorum* L.), Japanese brome (*Bromus japonicus* Thunb.), and rescuegrass [*Bromus unioloides* (Willd.) Kunth] along with wild oat (*Avena fatua* L.) and jointed goatgrass (*Aegilops cylindrica* Host.). Malik (1991) reported >95% control of wild oat with 0.16 lb ai ac^{-1} of fenoxaprop with minimal injury to seedling crested wheatgrass. Generally, tolerance studies that evaluate seedling wheatgrass response to herbicide application rate and timing are limited. Additional control methods or weed control systems that offer a means to reduce winter annual weed competition during seedling wheatgrass establishment should be evaluated.

Sulfosulfuron is a sulfonylurea herbicide that controls winter annual grass weeds such as downy brome and cheat (Olson et al., 2000a) and Japanese brome (Geier and Stahlman, 1996). Moderate control of rescuegrass has been observed (Baughman, 1998) and suppression of wild oat with sulfosulfuron has been reported (Olson et al., 2000b). Sulfosulfuron also controls or suppresses certain members of the mustard family: field pennycress (*Thlaspi arvense* L.), flixweed [*Descurainia sophia* (L.) Webb ex Prand], and shepherd's purse [*Capsella bursa-pastoris* (L.) Medic.] (Anon., 2000). Sulfosulfuron is currently used in winter and spring wheat (*Triticum aestivum* L.) production with excellent crop safety. However, research to evaluate wheatgrass response to sulfosulfuron is lacking.

The objective of this research was to evaluate three wheatgrass cultivars, CD II, Jose, and Manska, for tolerance to sulfosulfuron at three herbicide rates and three application timings.

MATERIALS AND METHODS

Two greenhouse studies (Trials 1 and 2) were conducted at the Texas Agricultural Research and Extension Center, Vernon, TX, and each Trial was repeated (A and B). Trial 1 was a preliminary assessment of potential herbicide sensitivity among cultivars, followed by Trial 2 with a higher number of plants to verify results from Trial 1. Sulfosulfuron application rates of 0.01, 0.02, and 0.04 lb ai ac^{-1} were used to evaluate the chemical's effect on three wheatgrass cultivars: CD II, Jose, and Manska. The labeled use rate for wheat is 0.03 lb ai ac^{-1}. Treatments were applied at preemergence (PRE), 2 weeks after emergence (2 WAE) at the 2-leaf stage, or 4 WAE at the 3- to 4-leaf stage using a four-nozzle CO_2 backpack sprayer equipped with XR110015 tips and calibrated to deliver 15 gal ac^{-1} at 40 psi. Plants were placed in the greenhouse (85/60 $\pm$ 5^{o}F day/night), watered daily, and fertilized with 2 x 10^{-4} lb of 15-30-15 (N-P_2O_5-K_2O) per pot. Following harvest, plant material was dried at 150^{o}F for 48 hrs before determining plant dry weights. Each treatment in each trial had its own set of controls. The percentage reduction in dry weight following a sulfosulfuron application was determined for each trial by comparing that treatment with the untreated control of that cultivar at each application time.

Run A of Trial 1 was initiated on 21 February 2001 and Run B about 4 wk later. Plastic 6-in-diam. pots were filled with 3.1 lb of Miles fine sandy loam (fine-loamy, mixed, thermic family of Udic Paleustalf, 7.1 pH and 0.1% organic matter), seeded, and placed in a greenhouse. Pots were thinned to two plants after emergence. Treatments were replicated six times with two plants per replication or a total of 12 plants per treatment per Run. Four weeks following the 4-WAE treatment, above-ground viable biomass was determined.

Run A of Trial 2 was initiated on 18 February 2002, and Run B about 6 wk later using seed from the same seed lot used in Trial 1. Seed were kept in cold storage and germination and viability remained good between Trial 1 and Trial 2. The three cultivars were planted in 1.5-in-diameter cone pots filled with 0.45 lb of the soil type used in Trial

1 and thinned to two seedlings per cone following emergence (seven cones per treatment). Eight weeks following each herbicide application, above-ground viable biomass was harvested (Harvest 1), leaving about 0.4 in of plant height for regrowth. Four weeks after the initial harvest, all above-ground viable biomass was collected (Harvest 2). The number of live plants following the second harvest was recorded. Following Harvest 2, soil was rinsed from plant roots and root biomass determined. The treatments were replicated four times in each Run for a total of 56 plants per treatment per run.

The experiment was arranged as a randomized complete block with factorial arrangement of cultivar by application time by application rate. Data were analyzed using Proc Mixed in SAS (SAS Inst. 1996). Runs A and B within each Trial were considered random variables.

RESULTS

The preliminary data of Trial 1 indicated there was cultivar sensitivity to sulfosulfuron herbicide (Table 1).

Table 1. Analysis of variance of plant counts and harvest weights using SAS PROC MIXED.

	-Trial 1-	------------------------Trial 2----------------------			
	Harvest Wt.	Harvest 1 Wt.	Harvest 2 Wt.	Harvest 2 Plant #	Harvest 3 Root Wt.
Cultivar (C)	***	***	***	***	***
Time (Tm)	*	***	ns†	***	**
Tm x C	*	ns	ns	ns	ns
Treatment (Trt)	***	***	***	***	***
C x Trt	***	***	***	***	ns
Tm x Trt	ns	**	ns	ns	ns
Tm x C x Trt	ns	ns	ns	ns	ns

* Significant at P < 0.05 , ** Significant at P < 0.01, *** Significant at P < 0.001,
† Not significant at P < 0.05

At first harvest, above-ground biomass averaged over treatment times was significantly higher for CD II than either Jose or Manska (Fig. 1) and when averaged over treatment rates at 2 and 4 WAE (Fig. 2).

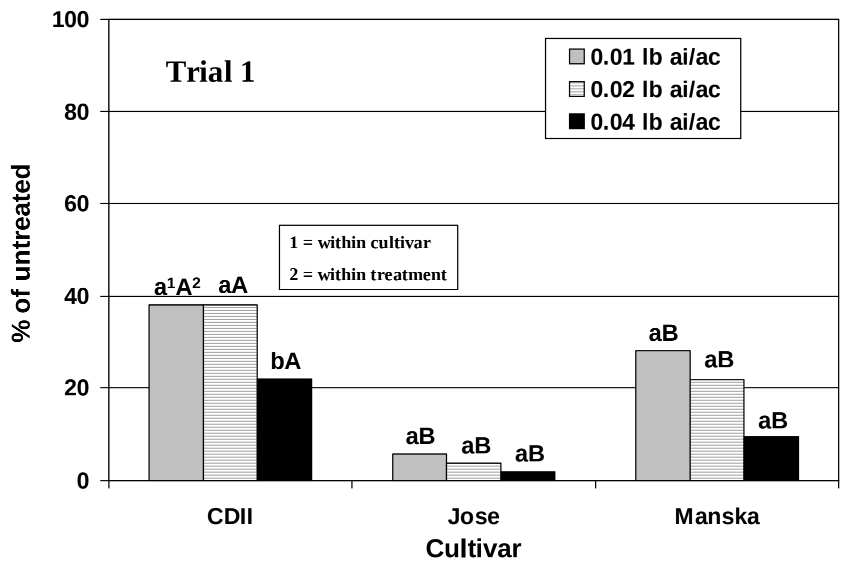

Figure 1. Above-ground biomass from first harvest averaged over treatment times.

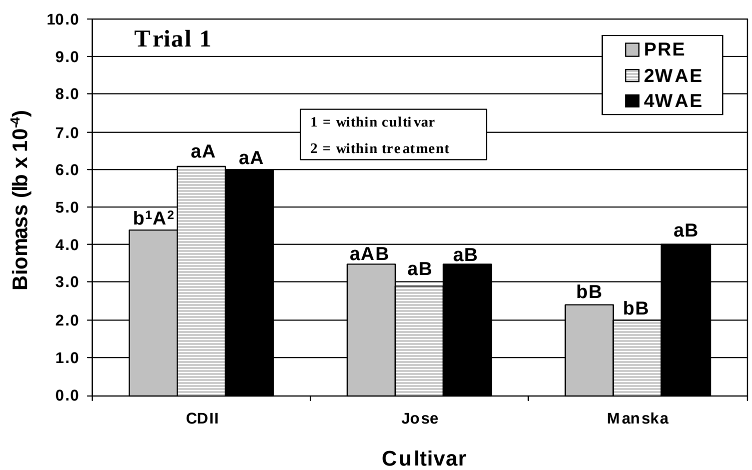

Figure 2. Above-ground biomass from first harvest averaged over treatment rates.

CD II generally showed greater tolerance to the herbicide than either Jose or Manska. Based on the results from this preliminary study, Trial 2 was initiated with a greater number of seedlings and further refined as to harvest timing.

In Trial 2, cultivar, time of treatment (except Harvest 2), and herbicide treatment were significant for above-ground biomass, number of surviving seedlings, and final root weights (Table 1). There were no interactions for root weight. Figure 3 shows the effects of increasing rates of sulfosulfuron, averaged across treatment times, on above-ground biomass for each wheatgrass cultivar at the first harvest date.

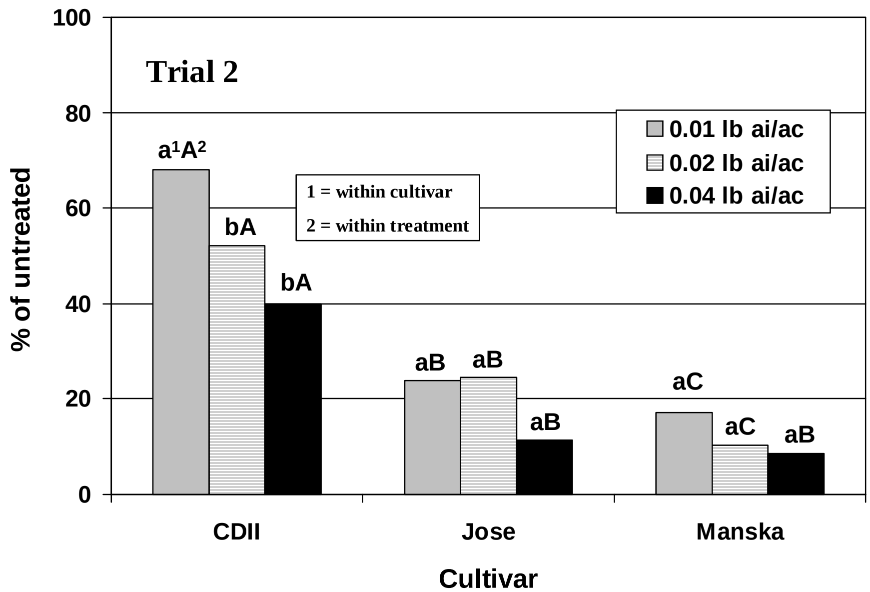

Figure 3. Above-ground biomass from first harvest averaged over treatment times.

It was quite evident that CD II was the most tolerant of the wheatgrasses at all herbicide rates and Manska was the most susceptible. Figure 4 shows the effect of treatment times and herbicide rate (averaged across wheatgrass cultivars) on loss of above-ground biomass at the first harvest date.

For post emergent applications, wheatgrasses were more susceptible when treated 2 WAE compared with 4 WAE. Across all treatments, the above-ground biomass from the second harvest was reduced more for Jose and Manska than CD II when compared with above-ground biomass from the first harvest (Figs. 3 and 5).

For post emergent applications, wheatgrasses were more susceptible when treated 2 WAE compared with 4 WAE. Across all treatments, the above-ground biomass from the second harvest was reduced more for Jose and Manska than CD II when compared with above-ground biomass from the first harvest (Figs. 3 and 5).

Manska was quite susceptible to all herbicide rates, with the higher rates resulting in nearly 100% loss of seedlings. CD II had the greatest number of surviving plants across all herbicide rates and timings.

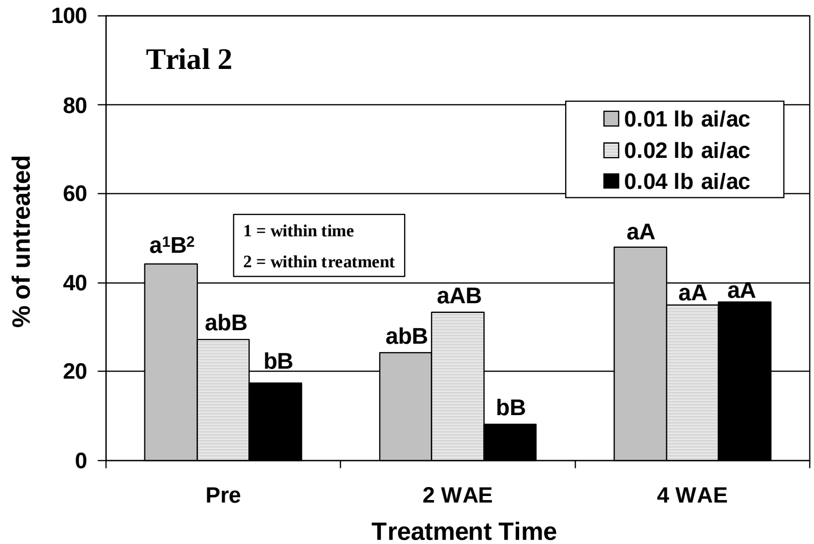

Figure 4. Above-ground biomass from first harvest averaged over cultivars.

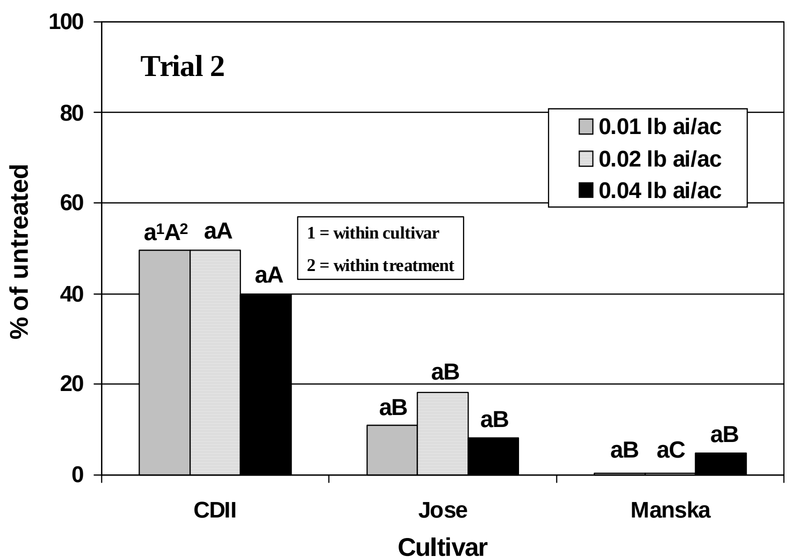

Figure 5. Above-ground biomass from second harvest averaged over treatment times

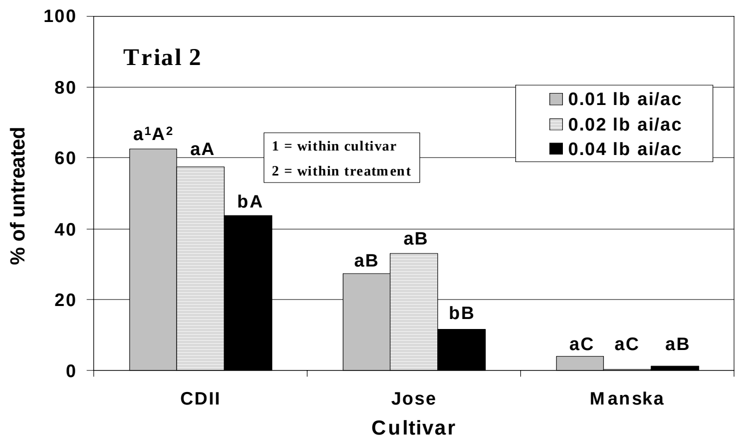

Figure 6. Number of live plants following second harvest averaged over treatment times.

Root mass showed a linear decrease with increasing herbicide rate and reflects the weakened condition of plants due to earlier leaf removal and the full effect of the herbicide treatment (Fig 7). Across all treatments and rates, CD II had the highest root mass, followed by Jose and Manska (data not shown).

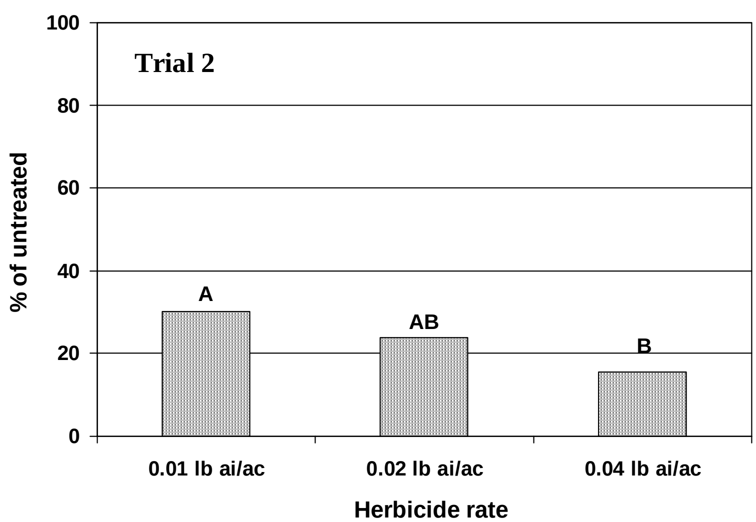

Figure 7. Root mass following second harvest averaged over treatment times and cultivars.

DISCUSSION

Differences in response to sulfosulfuron treatments for CD II compared with the other wheatgrasses may be partially explained by heterogeneity existing among plants due to its development from crossing two different wheatgrass species (Asay et al., 1997). *Agropyron cristatum*, a chemically induced tetraploid, was crossed with the naturally occurring tetraploid, *A. desertorum*, to form the hybrid, "Hycrest". A breeding program was initiated in 1985 to improve the Hycrest breeding population. Ten phenotypically similar clones were chosen out of the final breeding cycle and bulked to form CD-II breeder seed (Asay, et al., 1997). Apparently, one of the original parent species or a combination of the genetic material from the two crossed species in the 10 selected clonal lines provided some tolerance to sulfosulfuron.

Sulfosulfuron resistant downy brome has already been selected. Primisulfuron was applied to a downy brome population over a number of years, and resistance to primisulfuron developed. The primisulfuron-resistant downy brome was then screened for its response to sulfosulfuron, and cross-resistance to sulfosulfuron was identified (Mallory-Smith et al., 1999). Over a number of generations, selection pressure from repeated primisulfuron applications resulted in sulfosulfuron-resistant downy brome. Using similar procedures, it may be possible to select a CD II crested wheatgrass that is highly tolerant to sulfosulfuron.

Manska and Jose trace back to single plant introductions and may therefore constitute a small subset of the genetic variability within a population (Berdahl et. al, 1993; Anon., 1966). The narrow genetic base could contribute to Manska's and Jose's sensitivity to sulfosulfuron.

Greenhouse studies need to be followed by field evaluations, treating larger plant populations of CD II with sulfosulfuron, and selecting tolerant but fertile plants. Our data indicated that seedlings were generally most sensitive to herbicide treatment 2 WAE. This knowledge can be used to provide maximum selection pressure on seedlings in a large population of CD II. Over a number of generations it may be possible to develop a non-genetically engineered crested wheatgrass cultivar with high tolerance to sulfosulfuron. A highly tolerant sulfosulfuron crested wheatgrass would have significant implications in eliminating competing winter annual grass and broadleaf weeds during wheatgrass stand establishment. Furthermore, the possibility of developing tolerant, competing brome grass species is less likely with the establishment of a perennial forage like CD II than with an annual forage crop that would over time potentially receive multiple applications of the same herbicide.

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