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Tolerance of Meadow Foxtail (*Alopecurus pratensis*) to Two Sulfonylurea Herbicides

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Meadow foxtail is a rhizomatous grass widely grown for hay and pasture in wet meadows of the western United States and Canada. Two sulfonylurea herbicides, chlorsulfuron and metsulfuron-methyl, were evaluated for their effects on meadow foxtail biomass. Both herbicides were applied at four doses, 0.035, 0.070, 0.105, and 0.140 kg ai/ha, together with a control at each of two sites in October 2003. Treatments were replicated four times at each site and arranged in a randomized complete block design and sampled in July 2004 and 2005. Meadow foxtail biomass depended on site ($P = 0.001$) or year ($P = 0.001$), but not herbicide treatment ($P = 0.182$). No biomass production losses resulted from applying up to 0.14 kg/ha of either chlorsulfuron or metsulfuron-methyl on meadow foxtail, even in relatively high-pH soils.

Nomenclature: Chlorsulfuron; metsulfuron-methyl; meadow foxtail, *Alopecurus pratensis* L.

Meadow foxtail is a rhizomatous grass indigenous to the temperate parts of Europe and Asia (Hannaway and McGuire 1981). This grass is widely grown for hay and pasture in wet meadows of the western United States and Canada. Meadow foxtail is well-adapted to cool, moist environments, but can tolerate some drought (Hannaway and McGuire 1981). It is an early-growing cool-season grass that can grow throughout the winter in warmer climates. Meadow foxtail can withstand flooding and has survived in alkaline wetlands with a soil pH up to 8.5 (Schoth 1945).

Meadow foxtail now grows in hundreds of thousands of hectares of flood meadows throughout the United States and Canada and provides valuable hay and pasture for livestock. Tingle and van Adrichem (1974) reported that the yield of meadow foxtail averaged 2,100 kg/ha with a crude protein level of 9.5 to 22.4% depending on the growth stage at harvest, weather conditions, and haying techniques. This species produces as much biomass as orchard grass (*Dactylis glomerata* L.), and its nutrient value can exceed that of timothy (*Phleum pratense* L.) (Fairey 1991; Rode and Pringle 1986).

Invasion of meadow foxtail pastures by weeds is of increasing concern to livestock producers, especially weeds from the Brassicaceae (mustard) family of plants (Renz and DiTomaso 2006). One major weed in both native and nonnative grass meadows is perennial pepperweed (*Lepidium latifolium* L.). This invasive weed is indigenous to southeast Europe and southwestern Asia (Young et al. 1998). Perennial pepperweed can invade a wide range of habitats including riparian areas, wetlands, marshes, and floodplains. It creates large monospecific stands that displace native plants and animals and dramatically reduces perennial grass production (Young et al. 1998).

One effective herbicide for controlling perennial pepperweed and other members of the mustard family is chlorsulfuron. Young et al. (1998) reported that chlorsulfuron effectively controlled perennial pepperweed at 0.104 kg ai/ha. Similarly, metsulfuron-methyl effectively controls perennial pepperweed. One concern ranchers and farmers, industry sales representatives, and cooperative weed management personnel have expressed is that both herbicides injure meadow foxtail and affect the grass production the following year after application. Meadow foxtail discoloration and injury is also mentioned as a potential problem, especially in soils with a pH higher than 7.9 (Environmental Protection Agency reg. no. 352–439). Little is known about how these herbicides influence the production of meadow foxtail used for hay or whether one herbicide affects meadow foxtail more or less than the other.

The purpose of this study was to test and compare the influence of various rates of chlorsulfuron and metsulfuron-methyl on meadow foxtail biomass. I hypothesized that both herbicides would reduce meadow foxtail and forb biomass. I expected that the highest herbicide rates would yield the lowest meadow foxtail and forb biomass production. Because sedges (*Carex* spp.) are physiologically different from the other species and are very difficult to control, I had no reason to expect either herbicide to affect their biomass.

Materials and Methods

Study Sites. This study was conducted from 2004 to 2005 at two seasonally flooded hay meadow sites in the high desert about 5 and 8 km from Burns, OR. Soil at site 1 (43°518′N, 119°021′W) is a complex of Fine-silty, mixed frigid Cumulic Endoaqualls, Fine-silty, mixed (calcareous), frigid Cumulic Endoaquolls, and a Coarse loamy, mixed (calcareous), frigid Aeric Halaquepts that has a water table elevated above the soil surface until about the end of April.[1] Soils at site 2 (43°556′N, 119°045′W) is a fine-silty, mixed frigid Cumulic Endoaquolls with water at or near the soil surface through May. Both sites lie on flat land at an elevation of about 1,450 m. As happens every year on these flood meadows, each site was flooded beginning in early spring with natural snowmelt and spring rains, usually through April or May depending on the site; after May meadows were flooded from

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Table 1. P values from ANOVA of the effects of treatments, year, and site, and their interactions on grasses, sedges, and forb biomass. Overall model P > F is < 0.001 for each response variable. Coefficients of variation are 27, 45, and 144 for grasses, sedges, and forbs, respectively.

Source	Grasses	Sedges	Forbs
Rep	< 0.001	0.339	0.330
Treatment	0.182	0.450	0.196
Year	< 0.001	< 0.001	< 0.001
Site	< 0.001	< 0.001	< 0.001
Treatment*Year	0.281	0.557	0.008
Treatment*Site	0.138	0.825	0.101
Year*Site	0.679	< 0.001	< 0.001
Treatment*Year*Site	0.596	0.467	0.018

the Silvies River until the first part of June. Site 2 is closer to the river and stays wetter longer into the summer. Vegetation composition was dominated by meadow foxtail, assorted sedge species, and a few sparsely distributed native and nonnative forbs. Since this study focused on grass biomass production in response to two sulfonylurea herbicides, perennial pepperweed was not a portion of the species composition.

Experimental Design and Procedures. Four application rates of chlorsulfuron and four application rates of metsulfuron-methyl were applied at each site in October 2003. This is the typical time of application of these herbicides on perennial pepperweed in flood meadows.[1] Herbicide rates were 0.035, 0.070, 0.105, and 0.140 kg ai/ha. Herbicides were applied with a nonionic surfactant at a rate of 1 L/400 L of spray solution. Treatments were replicated four times at each site and arranged in a randomized complete block design. Herbicides were applied to 2 m by 2 m plots with a backpack sprayer propelled with CO_2 at 310 kPa delivering a solution of 117 L/ha with 8,004 nozzles.

Sampling and Analysis. Vegetation was clipped from three randomly placed 0.25-m^2 quadrats within each plot at peak standing crop (July) in 2004 and 2005. All plant material was clipped at ground level, dried to a constant weight (60 C for 48 h), separated into meadow foxtail, sedges, and forbs, and then weighed. Data were tested for homogeneity of variances and that assumption was met. Biomass data were analyzed using a split-plot in time analysis of variance, which is a repeated-measures analysis when 2 yr are included. Herbicide treatments and sites were tested using the mean squares for error from the complete model. Year and interactions including year were tested using the replication by treatment by site mean square as the error term. Means were separated using a Fishers Protected LSD test at 0.05 level of confidence.

Results and Discussion

The biomass of meadow foxtail depended on site or year, but not herbicide treatment (Table 1; Figure 1). Site 1 produced 4,330 (SE = 105) kg/ha of meadow foxtail, whereas site 2 only produced 2,170 (SE = 104) kg/ha across years and treatments. Across sites and treatments, 3,670 (SE = 104) and 2,830 (SE=105) kg/ha of grass biomass was produced in 2004 and 2005, respectively. Malik (1990) found that both metsulfuron and chlorsulfuron provided excellent control of field pennycress (*Thlaspi arvense* L), while increasing the yield of timothy by 29 to 52% over a 3-yr period. In that study, neither herbicide caused significant crop injury. Conversely, Machac (1995) found that timothy and meadow fescue (*Festuca pratensis* L) were sensitive to relatively low rates of chlorsulfuron. Despite manager concern and registration precautions, neither chlorsulfuron nor metsulfuron-methyl influenced biomass production at either site or year studied. This lack of response suggests that using these herbicides in flood meadows dominated by meadow foxtail will not cause major production losses.

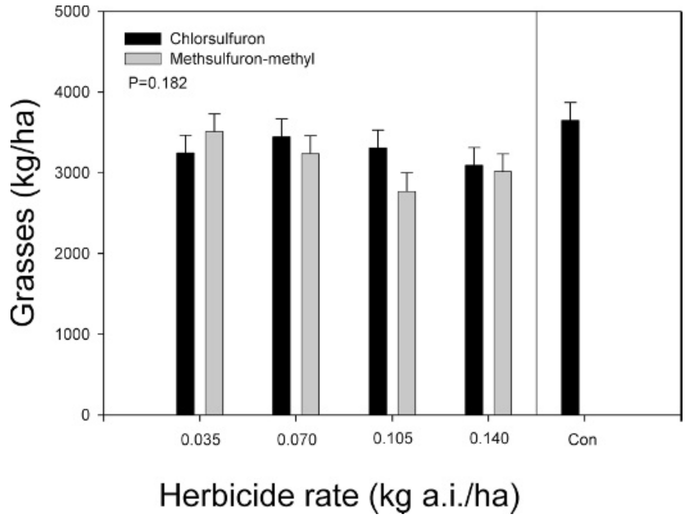

Figure 1. Meadow foxtail means biomass production after application of either chlorsulfuron or metsulfuron-methyl at various rates. Means are across years and sites. Bars represent 1 SE and no differences were detected.

Many factors such as high pH, prolonged cold weather, or wide fluctuations in day/night temperatures before or soon after application of these herbicides can cause discoloration or grass injury (Sarmah et al. 2000). Many of these factors are prominent in the high desert environments of eastern Oregon. It is possible that discoloration or grass injury occurs, but does not result in losses of biomass production. Soil pH at site 1 was 8.5 in the upper 36 cm.[3] Soil pH at site 2 was 8 in that zone. Although I anticipated the highest impacts of these herbicides on meadow foxtail at the highest application rate (0.14 kg/ha), no reductions in biomass production were detected in these high-pH soils with a prolonged cold season and wide fluctuations in day/night temperatures.[1]

The response of forbs to herbicide treatments was highly variable (Table 1). This was probably because the forbs were somewhat randomly clumped throughout the study areas. Overall, forb biomass production was very low and ranged from 0.0 to 160 kg/ha.[1]

Forb biomass response ranged from 10-fold reductions to 10-fold increases. There were no consistent trends, possibly because of the lack of uniform forb distribution before herbicide treatments (Peterson 1985).

As hypothesized, sedges did not respond to herbicides, but sedge biomass varied by site and year (Table 1). Across all herbicide treatments, site 1 produced 720 and 510 kg/ha of sedges in 2004 and 2005, respectively. At site 2, sedge biomass production increased from 2,340 kg/ha in 2004 to 3,610 kg/ha in 2005. Soils and proximity to the Silvies River provide a longer duration of flooding than site 1, which probably explains the higher sedge biomass.

In conclusion, no loss of meadow foxtail biomass production resulted from the application of either chlorsulfuron or metsulfuron-methyl at doses as high as 0.14 kg/ha, even in relatively high-pH soils. Although there was a trend toward lower meadow foxtail forage production (Figure 1), it was not statistically significant. The decision to use either metsulfuron-methyl or chlorosulfuron should be based primarily on sensitivity of the weedy species rather than sensitivity of meadow foxtail.

Sources of Materials

[1] www.soildatamart.nrcs.usda.gov/Report.aspx?Survey=OR628&UseState=OR.

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