Mefluidide Effects on Forage Quality of Crested Wheatgrass[1]

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ABSTRACT

Crested wheatgrass, (*Agropyron desertorum* [Fisch.] Schult), a valuable spring forage in semiarid environments, produces stiff reproductive shoots that become unpalatable and are of poor nutritive quality. Mefluidide (*N*-[2,4-dimethyl- 5{[(trifluoromethyl)sulfonyl]amino} phenyl]acetamide), a plant growth regulator, has the potential to reduce reproductive shoots and improve nutritive quality. Mefluidide was applied to crested wheatgrass, which was grown on coarse-loamy, mixed, frigid Orthid Durixerolls in May 1982 and 1983, at 0.14, 0.28, and 0.42 kg a.i. ha^{-1}. Herbage yield, density of reproductive shoots, and concentrations of ash, acid insoluble residues, total N (crude protein), in vitro digestible organic matter (IVDOM), and neutral detergent fiber (NDF) in accumulated forage during July through October were determined each year. Reproductive shoot density was reduced by mefluidide up to 91% in both years. The reduction in reproductive shoot density was accompanied by a 20 to 60% decrease in dry matter yields. Ash contents increased 50 to 70 g kg^{-1} with mefluidide application. A relatively large portion of the ash was acid insoluble residue (silica) and may have been the result of soil contamination on leaves of treated plants. Mefluidide also increased crude protein 18 to 19 g kg^{-1} and IVDOM 30 to 40 g kg^{-1}, and decreased NDF 50 to 80 g kg^{-1}. The greatest changes occurred with the 0.28 and 0.42 kg ha^{-1} rates. Major benefits of mefluidide applications include increased forage quality and decreased stemminess.

Additional index words: **Crude protein, In vitro digestible organic matter, Neutral detergent fiber, Ash, Herbage yields, *Agropyron desertorum*, Plant growth regulator.**

CRESTED wheatgrass (*Agropyron desertorum* [Fisch.] Schult), a common species for seeding semiarid rangelands, occupies approximately 8.2 million hectares in the western United States (Holechek, 1981). This species produces palatable and nutritious spring forage and withstands heavy spring grazing (Hyder and Sneva, 1963). A major disadvantage of crested wheatgrass is the production of stiff reproductive shoots that become unpalatable, are of poor nutritive quality, and do not decompose over winter.

Grazing plants in the boot stage removes floral primordia, stimulates tillering, and results in leafy nutritious herbage for grazing in late summer and fall (Hyder and Sneva, 1963). Paraquat (1-1′-dimethyl-4,4′-bipyridinium ion) used in late May has reduced floral primordia by 50 to 87% (Sneva, 1970). Paraquat applied in June cured herbage and increased levels of crude protein and P in forage saved until fall (Sneva, 1967). Nitrogen fertilizer plus paraquat increased yield and quality of crested wheatgrass forage utilized in the fall (Sneva, 1973). Lack of reliable summer and fall rainfall and lack of labeling of paraquat for curing herbage on rangelands restricts use of these techniques.

Mefluidide (*N*-[2,4-dimethyl-5{[(trifluoromethyl) sylfonyl] amino} phenyl] acetamide), a plant growth regulator, has been used in mesic habitats to reduce inflorescence development and improve forage quality of several grasses. The reported results with tall fescue (*Festuca arundinacea* Schreb.) (Glenn et al., 1980; Robb et al., 1982; Manurung, 1982), smooth brome (*Bromus inermis* Leyss.) (Wimer et al., 1986), perennial ryegrass (*Lolium perenne* L.) (Field, 1983; Manurung, 1982), and orchardgrass (*Dactylis glomerata* L.) (Allen et al., 1983) suggest that mefluidide may have the potential to manipulate crested wheatgrass. Studies were initiated in the spring of 1982 to test the hypothesis that spring application of mefluidide could reduce inflorescence development and improve quality of accumulated forage of crested wheatgrass during late summer and fall in the northern sagebrush steppe.

MATERIALS AND METHODS

Two study sites supporting solid stands of crested wheatgrass were located at the Squaw Butte Experimental Range, 65 km west of Burns, OR. Elevation at the sites is 1360 m. Precipitation totaled 279 and 320 mm in 1982 and 1983, with 187 and 173 mm, respectively, occurring during the March to October period. Soils were coarse-loamy, mixed, frigid Orthid Durixerolls.

Plots (3 by 27 m) were treated with mefluidide at 0, 0.14, 0.28, and 0.42 kg a.i. ha^{-1} on 14 May 1982, and a different set was treated on 14 May 1983. Foliage was sprayed with an aqueous solution of 90 L ha^{-1} at 2.1×10^5 Pa. Spray was applied just prior to floral differentiation in 1982 and during floral differentiation in 1983 when leaves were about 150 to 200 mm long. Plots were not fertilized, and the standing crop from the previous years had been removed to a 50-mm stubble height by mowing during the fall. Treatments were arranged in a split-plot design, replicated in six randomized blocks, with mefluidide rates as main plots and harvest dates as subplots randomly arranged in the main plots.

Dry matter yield was determined by hand clipping separate subplots (1.2 by 1.8 m) to a stubble height of approximately 10 mm, twice monthly, from 1 July to 15 October each year. Densities of reproductive shoots, with fully developed inflorescences, were determined on the subplots by counting prior to clipping in August each year.

Forage samples were dried at 60°C for 48 h, weighed, and ground in a Wiley mill to pass a 1-mm screen. Samples were analyzed for dry matter, organic matter, apparent in vitro digestible organic matter (IVDOM), neutral detergent fiber (NDF), acid insoluble residues (AIR), and total N content. Dry matter was determined by oven-drying at 100°C for at least 12 h. Oven-dried samples were then placed in a muffle furnace at 600°C for 2 h for organic matter determinations.

Apparent digestible organic matter was determined according to Goering and Van Soest (1970). Neutral detergent fiber was determined according to Van Soest and Wine (1967) and is presented as ash-free. Acid insoluble residue was determined employing the method of Mayland et al. (1975) modified by using a 5-g plant sample. Total nitrogen was determined by the Kjeldahl procedure (Association of Official Agricultural Chemists, 1970) and is expressed as crude protein ($N \times 6.25$) on an organic matter basis.

Analysis of variance was used to test the effects of rates, dates, and their interaction. Specific comparisons were made using orthogonal polynomials (Table 1).

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Table 1. Probability levels from sequential test of polynomial rate and date effects (A) and corresponding coefficients of determination (B).

	Reproductive shoots		Dry matter yield		Ash		AIR		Crude protein		IVDOM		NDF	
	1982	1983	1982	1983	1982	1983	1982	1983	1982	1983	1982	1983	1982	1983
(A)														
Rate	†	†	†	†	†	†	**	†	†	†	**	†	†	†
Linear	†	†	†	†	†	†	--	--	†	†	†	†	†	†
Quadratic	*	**	*	*	*	NS	--	--	**	NS	*	*	**	**
Date	--	--	*	**	†	†	†	†	†	†	†	†	†	†
Linear	--	--	NS	†	†	†	†	†	†	†	†	†	†	†
Quadratic	--	--	**	NS	†	**	†	NS	†	†	†	†	†	†
Cubic	--	--	NS	NS	NS	†	NS	*	†	NS	†	**	†	NS
Rate × Date	NS	NS	NS	**	NS	NS	NS	**	NS	*	NS	NS	NS	*
(B)														
Rate														
Linear	0.84	0.94	0.86	0.95	0.97	0.98	--	--	0.97	0.97	0.80	0.92	0.92	0.94
Quadratic	0.15	0.15	0.13	0.03	0.02	0.01	--	--	0.03	0.02	0.19	0.08	0.08	0.06
Date														
Linear	--	--	0.03	0.60	0.88	0.72	0.71	0.85	0.54	0.91	0.80	0.92	0.91	0.96
Quadratic	--	--	0.51	0.09	0.08	0.08	0.28	0.00	0.41	0.08	0.05	0.05	0.03	0.01
Cubic	--	--	0.15	0.03	--	0.12	--	0.15	0.02	--	0.06	0.01	0.02	--

*,** Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively. NS = not significant. † Significant at $P \leq 0.001$.

RESULTS

Reproductive shoot density decreased as mefluidide rate increased in both 1982 and 1983, and was only 10% as dense at the 0.42 kg ha^{-1} mefluidide rate as with no mefluidide (Table 1 and Fig. 1). Many inflorescences were reduced in size, and some remained clasped by the leaf sheaths. Many internodes continued to elongate, forming a distorted morphology, with some inflorescences protruding extravaginally through split leaf sheaths, or small reduced inflorescences emerging intravaginally on a twisted reproductive shoot.

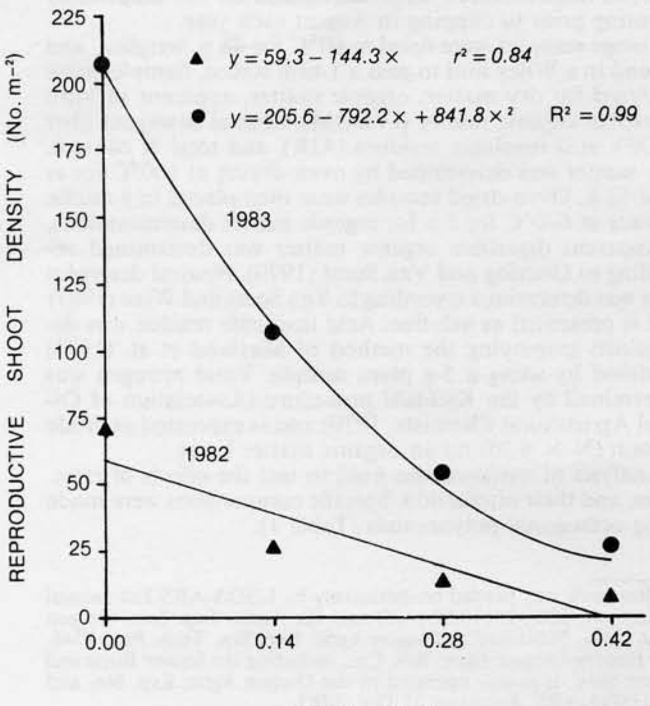

Fig. 1. Density of reproductive shoots, with fully developed inflorescences, of crested wheatgrass stands treated with mefluidide at 0, 0.14, 0.28, and 0.42 kg ha^{-1} during 1982 (▲) and 1983 (●).

Mefluidide reduced dry matter yields both years (Fig. 2). Yields averaged 810 kg ha^{-1} for treated plots in 1982, and this was consistently 20 to 40% less than averages for untreated plots. In 1983, 0.28 and 0.42 kg ha^{-1} of mefluidide reduced yield 45 to 50%, while the 0.14 kg ha^{-1} treatment reduced yield only 20%. A significant treatment × date interaction in 1983 resulted from sample variation and was not biologically significant.

Rate of mefluidide application and date of harvest had a significant effect on ash concentration in crested wheatgrass forage (Table 1 and Fig. 2). Averaged across dates, ash content of mefluidide-treated plants was higher than untreated plants by 21 to 46 g kg^{-1} in 1982, and 22 to 66 g kg^{-1} in 1983. The amount of ash contained in forage also increased as the season progressed. Analysis of AIR confirmed ash was mostly silica, and the AIR content of the control and the 0.28 kg ha^{-1} mefluidide-treated samples varied similarly when compared to ash ($R^2 = 0.98$ and 0.85).

Forage quality improved as mefluidide rate increased and reproductive shoot density decreased, probably due to an increase in proportion of leaves during 1982 and 1983. Crude protein content decreased 26 to 34 g kg^{-1} from July to mid-September both years and was significantly affected by mefluidide rates and date of harvest (Table 1 and Fig. 2).

Mefluidide-treated plants contained more IVDOM (Table 1 and Fig. 2) than did untreated plants. The IVDOM was similar for all three mefluidide rates in 1982, but was slightly greater for the two highest rates in 1983. The IVDOM declined continuously through September and October regardless of treatment. Similar IVDOM in September and October of 1982 was a result of regrowth due to fall rains.

Neutral detergent fiber was reduced by all rates of mefluidide, with the largest decreases resulting from the 0.28 and 0.42 kg ha^{-1} rates (Table 1 and Fig. 2). Neutral detergent fiber increased from July to October. The one exception, a stabilization in content occurring during 1 to 15 August each year, did not appear to be biologically significant.

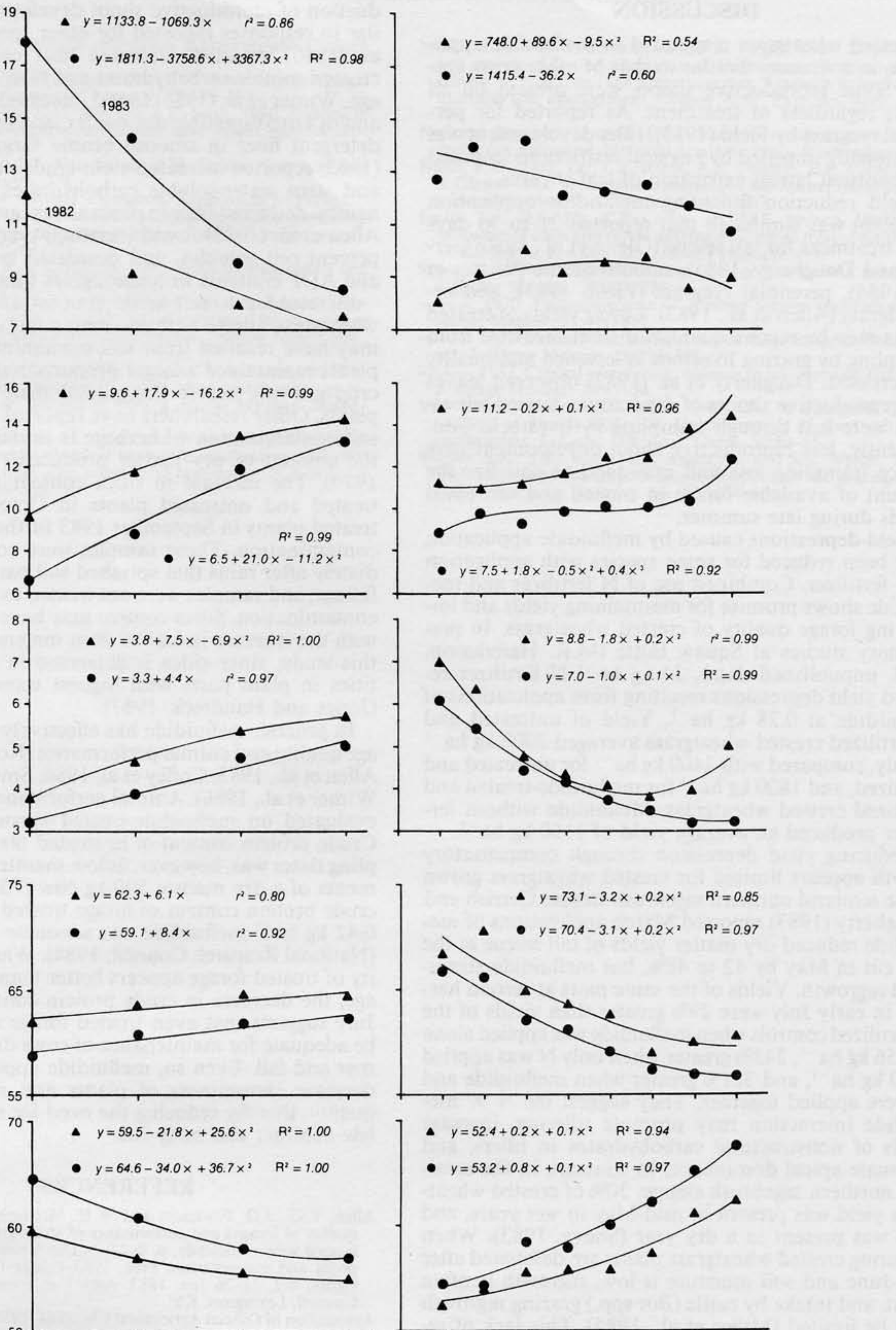

Fig. 2. Dry matter yield, ash, crude protein, IVDOM, and NDF contained in crested wheatgrass plants treated with mefluidide at 0, 0.14, 0.28, and 0.42 kg ha⁻¹ during 1982 (▲) and 1983 (●).

DISCUSSION

Crested wheatgrass responded to mefluidide application in a manner similar to that of other grass species. Some reproductive shoots were present on all plants regardless of treatment. As reported for perennial ryegrass by Field (1983), tiller development was occasionally impeded by physical restrictions imposed by abnormal lateral expansion of leaf sheaths.

Yield reduction following mefluidide application (20–60%) was similar to that reported 21 to 30 days after treatment for tall fescue (Glenn et al., 1980; Gerrish and Dougherty, 1983), smooth brome (Wimer et al., 1986), perennial ryegrass (Field, 1983), and orchardgrass (Allen et al., 1983). Lower yields of treated plants may be inconsequential if stem breakage from trampling by grazing livestock is lessened and quality is increased. Daugherty et al. (1982) observed leaves and reproductive shoots of dry mature crested wheatgrass were lost through trampling by livestock. Consequently, less reproductive shoot development may reduce trampling loss and may tend to equalize the amount of available forage in treated and untreated stands during late summer.

Yield depressions caused by mefluidide application have been reduced for some species with application of N fertilizer. Combined use of N fertilizer and mefluidide shows promise for maintaining yields and improving forage quality of crested wheatgrass. In preliminary studies at Squaw Butte (M.R. Haferkamp, 1983, unpublished data), 34 kg ha^{-1} N fertilizer reduced yield depressions resulting from applications of mefluidide at 0.28 kg ha^{-1}. Yield of untreated and unfertilized crested wheatgrass averaged 2000 kg ha^{-1} in July, compared with 2400 kg ha^{-1} for untreated and fertilized, and 1800 kg ha^{-1} for mefluidide-treated and fertilized crested wheatgrass. Mefluidide without fertilizer produced an average yield of 1150 kg ha^{-1}.

Reducing yield depression through compensatory growth appears limited for crested wheatgrass grown in the semiarid northern sagebrush steppe. Gerrish and Dougherty (1983) reported March applications of mefluidide reduced dry matter yields of tall fescue at the first cut in May by 42 to 48%, but mefluidide stimulated regrowth. Yields of the same plots at second harvest in early July were 29% greater than yields of the unfertilized controls when mefluidide was applied alone at 0.56 kg ha^{-1}, 245% greater when only N was applied at 80 kg ha^{-1}, and 321% greater when mefluidide and N were applied together. They suggest the N $\times$ mefluidide interaction may promote tillering, increase levels of nonstructural carbohydrates in tillers, and attenuate apical dominance. In contrast, in the semiarid northern sagebrush steppe, 30% of crested wheatgrass yield was present in mid-May in wet years, and 50% was present in a dry year (Sneva, 1983). When maturing crested wheatgrass plants are defoliated after mid-June and soil moisture is low, regrowth is often slight, and intake by cattle (*Bos* spp.) grazing regrowth may be limited (Miller et al., 1984). This lack of regrowth, due to limiting soil moisture, reduces the potential for decreasing yield depression in mefluidide-treated crested wheatgrass plants.

The increase in forage quality of crested wheatgrass following the application of mefluidide and the reduction of reproductive shoot development was similar to responses reported for other species. Glenn et al. (1980) reported decreased fiber content and increased soluble carbohydrates and N in tall fescue forage. Wimer et al. (1986) found increased crude protein and in vitro digestible dry matter, and reduced neutral detergent fiber in smooth brome forage. Manurung (1982) reported increased stem crude protein and leaf and stem water-soluble carbohydrates, and reduced neutral detergent fiber in perennial ryegrass forage, and Allen et al. (1983) found increased crude protein and percent cell solubles, and decreased cellulose, NDF, and ADF contents in orchardgrass forage.

Increased ash and silica concentration in crested wheatgrass foliage with increasing rates of mefluidide may have resulted from soil contamination. Treated plants maintained a larger proportion of the standing crop growing nearer the ground than did untreated plants. Other researchers have reported the amount of soil contamination of herbage is inversely related to the amount of dry matter produced (Metson et al., 1979). The increase in silica content found in both treated and untreated plants in October 1982 and treated plants in September 1983 further suggests soil contamination. These samples were collected immediately after rains that splashed soil particles onto the foliage, and samples were not treated to reduce surface contamination. Silica content may have also increased with the increase in leaf to stem material, assumed in this study, since silica is deposited in greatest quantities in plant parts with highest transpiration rates (Jones and Handreck, 1967).

In general, mefluidide has effectively improved forage quality and animal performance (Robb et al., 1982; Allen et al., 1983; Coffey et al, 1984; Smith et al., 1984; Wimer et al., 1986). Animal performance has not been evaluated on mefluidide-treated crested wheatgrass. Crude protein content of untreated plants at all sampling dates was, however, below maintenance requirements of a dry mature 500-kg cow (70 g kg^{-1}), while crude protein content of forage treated with 0.28 and 0.42 kg ha^{-1} mefluidide was adequate until mid-July (National Research Council, 1984). While forage quality of treated forage appears better than untreated forage, the decrease in crude protein content after mid-July suggests that even treated forage alone may not be adequate for maintenance of cows during late summer and fall. Even so, mefluidide application should decrease stemminess of plants and increase forage quality, thereby reducing the need for supplements in late summer and early fall.

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