3-1996

Suppression of Smooth Brome by Atrazine, Mowing, and Fire

Gary D. Willson
1National Biological Service, Columbia, MO

James L. Stubbendieck
University of Nebraska-Lincoln, jstubbendieck@unl.edu

Suppression of Smooth Brome by Atrazine, Mowing, and Fire

GARY D. WILLSON[1] and JAMES STUBBENDIECK[2]

[1]National Biological Service, Central Plains/Ozark Plateau Field Station, Columbia, MO 65211

[2]Department of Agronomy, University of Nebraska, Lincoln, NE 68583

ABSTRACT-- Burning and mowing were evaluated in 1989-1991 at Pipestone National Monument, Minnesota, as alternatives to atrazine to suppress smooth brome (*Bromus inermis* Leyss.) and to affect seeding success of big bluestem (*Andropogon gerardii* Vitman). Atrazine was the only treatment that significantly reduced smooth brome tiller density (-77% 1990; -70% 1991) as compared to unburned controls. Neither burning (-16% 1990; -37% 1991) nor mowing (-16% 1990; +10% 1991) resulted in significant reductions. Sod-seeded big bluestem failed in all treatments in both years. The failure of chemical and non-chemical management to affect sufficient smooth brome control for big bluestem seeding success exemplify the difficulties in restoring native and seeded prairie.

Key words: smooth brome, big bluestem, prescribed fire, mowing, atrazine, sod-seeding.

Several herbicides, including atrazine [2-chloro-4-(ethylamino)-6-(isopropyl amino)-s-triazine], have been used to control introduced smooth brome (*Bromus inermis* Leyss.) in order to enhance the vigor of remnant warm-season grasses or to suppress existing sod before seeding. For example, in southeastern Nebraska in overgrazed native pastures dominated by smooth brome, Waller and Schmidt (1983) found atrazine, applied in late April at 2.2 kg/ha, shifted dominance from cool- to warm-season grasses. First year results showed atrazine reduced the relative species composition of smooth brome by 91% compared to the control. In south central Nebraska, Dill et al. (1986) found that atrazine applied once in the spring at 3.3 kg/ha reduced smooth brome dominance in seeded warm-season pastures when remnants such as big bluestem (*Andropogon gerardii* Vitman) were present. Also in south central Nebraska, Bush et al. (1987) found application of atrazine at the time of seeding big bluestem and other warm-season grasses was an effective sod suppression treatment.

Atrazine suppresses smooth brome but may also impact native prairie species. For example, at the Samuel H. Ordway, Jr. Memorial Prairie, South Dakota, Plumb (1988) found atrazine applied at two rates (2.2 and 3.3 kg/ha) in the fall negatively affected both C_3 and C_4 native plants in a seeded area heavily infested with smooth brome. Similarly, atrazine applied at 1.1 kg/ha reduced standing crop of prairie forbs by 74% on a loam soil in west Texas (Peterson et al. 1983). In a restoration study in eastern Nebraska, Bragg and Sutherland (1989) found no seeded forbs in any plot treated with either atrazine or 2,4-D [(2,4-dichlorophenoxy)acetic acid] due either to the effect of the herbicide or to strong competition from seeded grasses, such as switchgrass (*Panicum virgatum* L.). Rosburg and Glenn-Lewin (1992) found atrazine decreased several annual forbs but the effect was significant only in the year of treatment. Considering these various effects, Gillen et al. (1987) concluded that atrazine application should be avoided if enhancement of forb diversity of a prairie is a primary objective of a restoration.

As an alternative to atrazine, mowing or prescribed fire has been suggested as a means to suppress smooth brome when applied at a critical growth stage. For example, Teel (1956), Reynolds and Smith (1962), and Eastin et al. (1964) demonstrated that smooth brome was most easily damaged by intensive defoliation after tiller internode elongation began in the spring. Furthermore, in eastern Nebraska, Willson (1991) showed a 50% reduction in smooth brome tiller density after a prescribed burn at the time of tiller elongation (mid-May). Kirsch and Kruse (1972) also found cover of smooth brome decreased by 50% or more after a 26 May burn in North Dakota, presumably at tiller elongation or after.

The advantage of mowing or burning is that these treatments may avoid the potential negative effects of herbicides on prairie forbs while producing sufficient smooth brome sod suppression to allow warm-season grass establishment following seeding. In order to assess any such advantages, our study was designed to compare the effects of atrazine, fire, and mowing on the suppression of smooth brome and evaluate the impacts of sod suppressing treatments on seedling establishment of big bluestem.

MATERIALS AND METHODS

Study site

The study was conducted on a 32 ha oldfield in management unit four within Pipestone National Monument, a national park unit in the Prairie Couteau region of southwestern Minnesota (44 1' N, 96 19' W; 512 m above sea level). The site was purchased by the National Park Service in 1956. Prior to that time, the site was used for row crop production. The site has been burned in early April to mid-May on a 3- to 4-year cycle since 1972. In 1989, the oldfield was dominated by seeded smooth brome and Kentucky bluegrass (*Poa pratensis* L.), 60% and 23% cover, respectively, but native prairie forbs had invaded from adjacent native prairie (Becker 1986). Included among these forbs were smooth blue aster (*Aster laevis* L.), purple prairieclover (*Dalea purpurea* Vent.), prairie wild rose (*Rosa arkansana* Porter), and whorled milkweed (*Asclepias verticillata* L.). Except for tall dropseed (*Sporobolus asper* (Michx.) Kunth), native grasses were absent. The soils of the site are classified as fine-silty, mixed Udic Haploborolls developed on loess over glacial till (Hokanson et al. 1976). Precipitation during spring and summer was highly variable but near the long-term average in 1990 and below average in 1991 (Table 1) (NOAA 1990, 1991).

Treatments

In September 1989, 16, 6 x 12 m plots were established at the oldfield site in a randomized complete block design which allowed four replications of four treatments. September smooth brome tiller density was determined for each plot by counting all current-year tillers within 10, 0.1m^2 randomly placed microplots and was the blocking criterion. Plots were separated by a 12-m lane to eliminate herbicide drift to adjacent plots. In September 1990, 12 new, 6 x 12 m plots were established at the same site but in a completely randomized design. In 1990, replicates were reduced to three because of limited space.

Treatments were herbicide (atrazine), mow-and-rake, prescribed burn, and no treatment (control). Treatments were applied 19-20 May, 1990, and 22-23 May, 1991, when approximately 50% of the smooth brome tillers showed internode elongation. A single application of atrazine at 2.2 kg/ha was broadcast over the herbicide plots with a hand sprayer. Mow-and-rake plots were cut to 4-cm stubble height and raked to remove cuttings. Burn plots were treated using a back fire (Wright and Bailey 1982) under the following prescription: temperature between 10 and 27C, wind from any direction between 16 and 32 km/hr, and relative humidity between 30 and 70%. The day following treatment applications, a mix of big bluestem seed previously collected from the park and purchased from a commercial source in eastern South Dakota, was sod-seeded (see Samson and Moser 1982) in all plots at 25

PLS/0.1 m^2 with a Truax native grass drill in 1990 and a John Deere Powr-Till seeder in 1991.

Evaluations

During September 1990 and 1991, sod suppression was determined by counting smooth brome tillers in three randomly located (0.1 m^2) microplots per treatment plot. Also in September 1990 and 1991, big bluestem seeding success was evaluated along five randomly located 1-m long transects per treatment plot that had been permanently marked along drill rows at the time of seeding. Each meter-long transect was divided into 20, 5-cm row segments. If 10% or more of the segments were occupied by one or more big bluestem seedlings, it was considered an acceptable stand. This acceptance level is approximately equal to at least 10 seedlings/m^2, which is considered to be a good stand by the Great Plains Agricultural Council (Launchbaugh 1966).

All data were subjected to either an analysis of covariance (1989 plots) or an analysis of variance (1990 plots). An F-protected LSD test was used to separate the treatment means in both experiments (alpha level of 0.05). The analyses were performed using SOLO statistical software (BMDP Statistical Software Inc. 1991).

RESULTS AND DISCUSSION

Sod Suppression

Atrazine was the only treatment to significantly decrease smooth brome tiller densities (77% in 1990 and 70% in 1991) from untreated controls ($P=0.0004$, $P=0.02$) (Fig. 1). The reduction in smooth brome tillers following atrazine applications in our study was consistent with the results from other herbicide studies (Waller and Schmidt 1983, Dill et al. 1986, Plumb 1988, Rosburg and Glenn-Lewin 1992).

Although burning reduced smooth brome densities by 16% in 1990 and 37% in 1991, post-treatment values were not significantly different from the untreated controls ($P=0.29$, $P=0.17$) (Fig. 1). The reduction in smooth brome density following fire was not as great as the reduction in a companion study at Mead, Nebraska, (Willson 1991), nor in other studies reported from the Midwest (Old 1969, Kirsch and Kruse 1972, Boehner 1986) even though the application of fire at Pipestone was timed to correspond with the period of smooth brome tiller internode elongation. At this stage, fire kills the tiller by removing the growing point and secondary tillering is reduced as a result of low carbohydrate reserves (Kuneluis et al. 1974). The difference between the responses at Pipestone and Mead was most likely due to differences in interspecific interactions. At the Pipestone study site, smooth brome was the dominant grass with a cover estimate of over 50% (Becker 1986). At Mead, smooth brome and big bluestem were co-dominates (T. Bragg, pers. comm.). Although the Pipestone burn treatment was timed to kill smooth brome tillers and minimize secondary tiller production, secondary tillers were not subjected to competitive stress due to the lack of a warm-season grass component at the study site.

As with burning, a single mowing in May had no significant effect on smooth brome tiller density although density decreased 16% in 1990 and increased 10% in 1991 (P=0.31, P=0.68) (Fig. 1). The absence of significant effects of mowing may have been due to mowing above a majority of the tiller growing points. Mowing height and the uneven ground surface in the plots could result in cutting that would not significantly affect smooth brome. Also, as in the burn plots, secondary tillers were not affected by the presence of warm-season grasses.

Sod-Seeding Big Bluestem

Sod-seeding big bluestem was unsuccessful (zero seedlings in September) for all treatments in both 1990 and 1991. The reasons for this were not apparent, since seeds were viable (germination tested at 76% in 1990 and 88% in 1991) and seed to soil contact had been maximized. The absence of any seedling establishment in 1990 prompted the change from a grass drill to a power seeder for better seed-to-soil contact and potentially greater germination.

Weather may have been a factor, since precipitation following sod-seeding was below normal most of the growing season months in both years (Table 1). Such conditions have been shown to affect big bluestem establishment (Bush et al. 1989). Bush et al. (1989), however, also found that with favorable precipitation, sod-seeding resulted in a complete stand failure in 1981, but a successful stand in 1982. No explanation for the difference is apparent.

Another possible explanation for seeding failure may be related to the degree treatments suppress existing sod. Competition from resident plants must be removed in order to establish seeded grasses (Sprague et al. 1960, Bush et al. 1989). For example, in upland pastures dominated by Kentucky bluegrass, Samson and Moser (1982) found sod-seeded switchgrass stands were successful only with 85% or greater suppression of residual herbage. In our study, maximum suppression of smooth brome tiller density was 16% following mowing and 37% following fire. Both treatments probably did not suppress smooth brome sod enough to allow big bluestem seedling survival. In the atrazine plots, reductions in smooth brome tiller densities were large (77% and 70%) in both years of our study, but also may have been insufficient to allow big bluestem seedlings to survive.

Table 1. Total monthly precipitation (cm) and departures from normal monthly means for April - September 1990 - 91 at Pipestone, Minnesota.

	1990		1991	
Month	Precipitation	Departure	Precipitation	Departure
April	3.95	-1.60	5.33	-0.23
May	12.08	3.45	7.95	-0.68
June	10.10	-0.23	8.20	-2.13
July	12.68	5.25	3.70	-3.73
August	7.93	-0.55	5.63	-2.85
September	1.03	-6.10	11.48	4.35

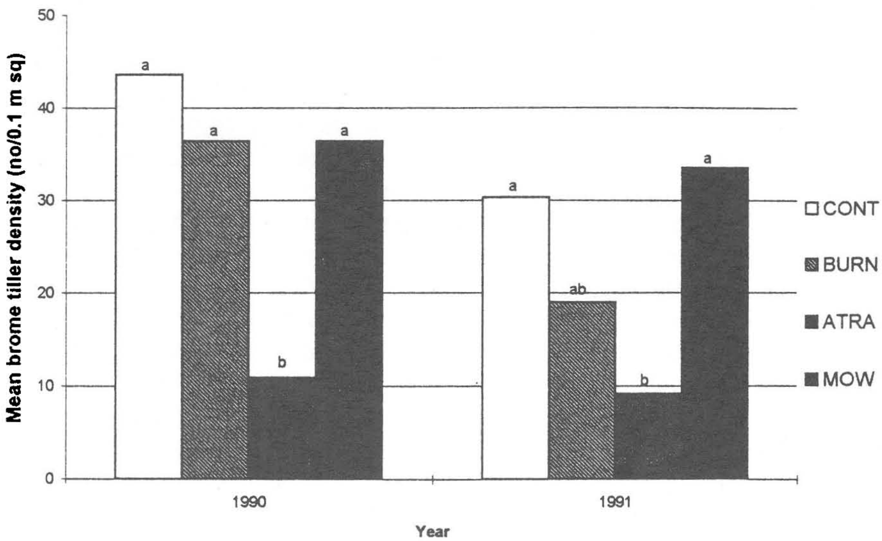

Figure 1. Mean smooth brome tiller density per 0.1 m^2 following treatments (CONT = unburned control, BURN = prescribed burn, ATRA = herbicide (atrazine), and MOW = mow-and-rake) in 1990-91 at Pipestone National Monument, Minnesota. Means with the same letter within years are not significantly different (P>0.05, LSD).

MANAGEMENT IMPLICATIONS

Restoration of degraded prairie dominanted by smooth brome and without remnant warm-season grasses may be limited to herbicide treatments, such as atrazine, followed by sod-seeding. However, sod-seeding is not always successful. Factors that may account for seeding failure include reduction of sod (Samson and Moser 1982), precipitaion following seeding (Bush et al. 1989), or other unknown factors (Bush et al. 1989). In our study, atrazine reduced smooth brome tiller density, but sod-seeding big bluestem failed possibly due to inadequate sod suppression, low precipitation following seeding, or both. Futhermore, herbicide use in certain restorations may be restricted due to the presence of sensitive species, such as native forbs. Our results exemplify the difficulties in restoring native and seeded priairie dominated by smooth brome.

LITERATURE CITED

Becker, D.A. 1986. Vegetation survey of Pipestone National Monument. Final report to the National Park Service, Midwest Regional Office, Omaha, NE.

BMDP Statistical Software, Inc. 1991. Solo statistical system, Los Angeles, CA.

Boehner, P.R. 1986. Effect of pre-burn artificial litter and prescribed burning on smooth brome (*Bromus inermis* Leyss.). M.S. Thesis. University of Nebraska, Lincoln.

Bragg, T.B., and D.M. Sutherland. 1989. Establishing warm-season grasses and forbs using herbicides and mowing. Pp. 81-89 *in* Proceedings of the Eleventh North American Prairie Conference (T.B. Bragg and J. Stubbendieck, eds.). University of Nebraska, Lincoln, NE.

Bush, B.L., S.S. Waller, B.E. Anderson, L.E. Moser, and R.M. Wozniak. 1989. Sod seeded warm-season grass with and without sod supression. Pp. 75-79 *in* Proceedings of the Eleventh North American Prairie Conference (T.B. Bragg and J. Stubbendieck eds.). University of Nebraska, Lincoln, NE.

Dill, T.O., S.S. Waller, K.P. Vogel, R.N. Gates, and W.W. Stroup. 1986. Renovation of seeded warm-season pastures with atrazine. J. Range Manage. 39:72-75.

Eastin, J.D., M.R. Teel, and R. Langston. 1964. Growth and development of six varieties of smooth bromegrass (*Bromus inermis* Leyss.) with observations on seasonal variation of fructosan and growth regulators. Crop Sci. 4:555-559.

Gillen, R.L., D. Rollins, and J.F. Stritzke. 1987. Atrazine, spring burning, and nitrogen for improvement of tallgrass prairie. J. Range Manage. 40:444-447.

Hokanson, H.L., F.D. Lorenzen, J.J. Murray, and R.O. Paulson. 1976. Soil survey of Pipestone County, Minnesota. U.S. Department of Agriculture - Soil Conservation Service.

Kirsch, L.M., and A.D. Kruse. 1972. Prairie fires and wildlife. Proceedings of the Tall Timbers Fire Ecology Conference 12:289-303.

Kuneluis, H.T., L.B. Macleod, and F.W. Calder. 1974. Effects of cutting management on yields, digestibility, crude protein, and persistence of timothy, bromegrass, and orchard grass. Can. J. Plant. Sci. 54:55-64.

Launchbaugh, J.L. (ed.). 1966. A stand establishment survey of grass plantings in the Great Plains. Great Plains Council Report 23, Lincoln, NE.

National Oceanic and Atmospheric Administration (NOAA). 1990. Local climatological data, Pipestone, Minnesota. National Climatic Data Center, Asheville, N.C.

National Oceanic and Atmospheric Administration (NOAA). 1991. Local climatological data, Pipestone, Minnesota. National Climatic Data Center, Asheville, NC.

Old, S.M. 1969. Microclimate, fire, and plant production in an Illinois prairie. Ecol. Monogr. 39:355-384.

Peterson, J.L., R.L. Potter, and D.N. Ueckert. 1983. Evaluation of selected herbicides for manipulating herbaceous rangeland vegetation. Weed Sci. 31:735-739.

Plumb, G. 1988. Atrazine of little value on a native grassland reseeding (South Dakota). Restor. Manage. Notes 6:90-91.

Reynolds, J.H., and D. Smith. 1962. Trend of carbohydrate reserves in alfalfa, smooth bromegrass, and timothy grown under various cutting schedules. Crop Sci. 2:333-336.

Rosburg, T.R., and D.C. Glenn-Lewin. 1992. Effects of fire and atrazine on pasture and remnant prairie plant species in southern Iowa. Pp. 107-112 *in* Proceedings of the Twelfth North American Prairie Conference (D.D. Smith and C.A. Jacobs eds.). University of Northern Iowa, Cedar Falls, IA.

Samson, J.F., and L.E. Moser. 1982. Sod-seeding perennial grasses into eastern Nebraska pastures. Agron. J. 74:1055-1060.

Spraque, M.A., R. D. Ilnicki, R.W. Chase, and A.H. Kates. 1960. Growth of forage seedlings in competition with patrially killed grass sod. Crop Sci. 2:52-55.

Teel, M.R. 1956. The physiological age of bromegrass (*Bromus inermis* Leyss.) as it affects growth rate following defoliation. Ph.D. Dissertation. Purdue University, Lafayette, IN.

Waller, S.S., and D.K. Schmidt. 1983. Improvement of eastern Nebraska tallgrass range using atrazine or glyphosate. J. Range Manage. 36:87-90.

Willson, G.D. 1991. Morphological characteristics of smooth brome used to determine a prescribed burn date. Pp. 113-116 *in* Proceedings of the Twelfth North American Prairie Conference (D.D. Smith and C.A. Jacobs eds.). University of Northern Iowa, Cedar Falls, IA.

Wright, H.A., and A.W. Bailey. 1982. Fire ecology, United States and Southern Canada. John Wiley and Sons, New York.

Received: 8/26/95 Accepted: 9/24/96