Improvement of Eastern Nebraska Tallgrass Range Using Atrazine or Glyphosate

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Abstract

Two herbicide treatments were initiated in southeastern Nebraska on a Wymore silty clay loam (clayey range site) during the spring of 1979, to change species composition of overgrazed, native range from cool- to warm-season grasses. Treatments consisted of late spring applications of atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazione] at 2.24 kg/ha, and glyphosate [*N*-(phosphonomethyl)glycine] at 1.12 kg/ha. Both herbicide treatments significantly ($P<.05$) reduced smooth brome (*Bromus inermis* Leyss.) and Kentucky bluegrass (*Poa pratensis* L.) production and relative species composition while increasing big bluestem (*Andropogon gerardii* Vitman) in 1979 and the effects were maintained during the second growing season. Warm-season herbage yield, primarily big bluestem, was greater following herbicide treatments (5345 kg/ha) compared to control (1610 kg/ha). Herbage yields of cool-season grasses from herbicide treated plots were reduced. However, total herbage yield was higher on herbicide treated plots during the first and second year after treatment. Total, warm-season and cool-season herbage yields for both years were not different between atrazine and glyphosate treated plots. Both herbicide treatments have potential for rapid recovery of overgrazed, native tallgrass prairies in eastern Nebraska when sufficient warm-season tallgrass remnants are present.

The eastern one-third of Nebraska was described as the True Prairie (Weaver 1954) and the native plant community was a tallgrass bluestem prairie, composed of warm-season vegetation. Currently, much of the area is in cropland. Remaining native range occurs as small scattered tracts of land which are generally unsuited for cultivation due to rocky or shallow soils or erosion hazards. Over 1 million acres of native range are located in this area (Bose 1977).

Over 60% of the native pasture in eastern Nebraska is in low range condition (Bose 1977). The availability of high producing cool-season species for hay and pasture and accessibility of crop residues encourage high stocking rates, often above the available summer forage supply. This imbalance in seasonal forage supply often contributes to range deterioration.

High stocking rates and season-long grazing characteristic of this area contributed to a shift in species composition from the warm-season native community, to cool-season species, primarily Kentucky bluegrass (*Poa pratensis* L.) and smooth brome (*Bromus inermis* Leyss.). Although forage is readily available in the spring, fall and winter with improved cool-season species and crop residues, a void of high quality summer forage exists which could be minimized by shifting species composition of the native pastures to native warm-season dominants.

Atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine], a soil active herbicide, has been reported to be phytotoxic to cool-season species (Houston 1977). Atrazine applications have been successful in controlling annual brome species (*Bromus* spp.) on western rangelands (Chamberlain et al. 1974, Morrow et al. 1977). Other range uses of atrazine have included weed suppression for establishment of perennial range grasses (Eckert and Evans 1967, Moomaw and Martin 1978) and weed control in existing pure stands of perennial grasses for seed production (McCarty et al. 1967, Peters and Lowance 1975).

Atrazine application increased the quantity and quality of tallgrass forage from a tallgrass prairie in north central Oklahoma (Baker and Powell 1978). On a shortgrass range in northeastern Colorado, applications of 2 kg/ha for 3 consecutive years completely controlled annual species, reduced the frequency of occurrence of cool-season species, and increased the drought survival of warm-season perennial grasses and 2 warm-season perennial forbs (Houston 1977).

Glyphosate [*N*-(phosphonomethyl)glycine], a nonselective post-emergent herbicide, has been used since its release in Europe for sward suppression in cool-season pasture renovation (Oswald 1976). However, its use in the United States and surrounding areas is fairly recent. Glyphosate was used in renovation of an overgrazed, predominantly cool-season grass pasture in Nebraska (Martin and Moomaw 1974). Applications (2.24 kg/ha) were made in the late spring and 6 warm-season grasses were seeded into the sod. Control of Kentucky bluegrass and Japanese brome (*Bromus japonicus* Thunb.) was excellent. Since native warm-season grasses were dormant at the time of spraying, they were not affected by glyphosate. However, the cool-season grasses were actively growing and effective control was obtained.

Research was initiated to evaluate the potential of atrazine and glyphosate to promote rapid recovery of warm-season native grasses through suppression of cool-season species on overgrazed, native pastures in Eastern Nebraska. It was assumed that adequate populations of warm-season grass remnants remained. Improvement in range condition through proper grazing management is well documented, but the response requires extended periods of time. Reducing time required to increase range condition was sought with herbicide treatments.

Experimental Procedure

Study Area

Research was conducted in southeastern Nebraska in Gage County, 7.2 km south of Virginia, Neb. The site has been grazed annually since 1961. Prior to that time, it was used as a native hay meadow. The research area was located on a clayey range site (Wymore silty clay loam–fine, montmorillonitic, mesic Aquic Argiudoll) (Beesley et al. 1964).

A continental climate dominates the area. Average annual precipitation ranges from 63 to 89 cm with approximately 80% occurring in the growing season of April to September (Beesley et al. 1964). Mean average temperature ranges from 5 to 12° C. Average freeze-free period is 170 days, with an average first freeze on October 13 and an average last freeze on April 26. The average grazing period in Gage County is from May 1 to October 31.

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Climax vegetation is Tallgrass Prairie dominated by switchgrass (*Panicum virgatum* L.), big bluestem (*Andropogon gerardii* Vitman), indiangrass [*Sorghastrum nutans* (L.) Nash], and little bluestem [*Schizachyrium scoparium* (Michx.) Nash]. The plant community prior to treatment was dominated by smooth brome, annual brome species, Kentucky bluegrass, tall dropseed [*Sporobolus asper* (Michx.) Kunth.], and broadleaf weed forbs such as western ironweed (*Vernonia baldwini* Torr.) and goldenrod (*Solidago* spp.).

Methods

A single application of atrazine (AAtrex 4L)[3] at 2.24 kg/ha or glyphosate (Roundup) at 1.12 kg/ha was made on April 21, 1979. Herbicides were applied using a water solution (189 l/ha). Plots (8.2 m × 13.7 m) were arranged in a randomized complete block and replicated 4 times. Plots were protected from grazing during the study. No further herbicide application was made during the study; however, standing vegetation was removed prior to growth initiation in 1980 to facilitate sampling procedures.

Relative species composition was obtained in April, 1979, prior to treatment, and August, 1979, and in May and September, 1980. A modified belt transect (1 m × 1 cm) was used to determine relative species composition (Conard 1953). Relative species composition was determined by counting the basal culms of each species that occurred in the belt transect. Multivariate analysis was used to evaluate treatment by date interaction ($P<.05$) for relative species composition (Stroup and Stubbendieck 1983).

Herbage yield was determined for each plot monthly in 1979, beginning in May to September and 4 times in 1980, beginning in June. Four, randomly located quadrats (.3 m × .6 m) were hand clipped by species at ground level and material was separated into living plant material by species, standing dead vegetation and litter. Samples were oven-dried for 48 hours in a forced air oven at 68° C and weighed.

Yields from each harvest date within years were subjected to analysis of variance. Preplanned, orthogonal contrasts were used to further delineate the treatment response ($P<.05$) (Steel and Torrie 1960). Total herbage yield consisted of all above-ground green vegetation. Warm-season herbage yield was the sum of the individual yields of big bluestem, little bluestem, switchgrass, indiangrass, sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], tall dropseed, and prairie dropseed [*Sporobolus heterolepis* (A. Gray) A. Gray]. Cool-season herbage yield consisted of all cool-season species: Kentucky bluegrass, smooth brome, annual bromes, Wilcox's dichanthelium [*Dichanthelium oligosanthes* (Schult.) Gould var. *wilcoxianum* (Vasey) Gould and Clark], Scribner's dichanthelium [*Dichanthelium oligosanthes* (Schult.) Gould var. *scribnerianum* (Nash) Gould], and porcupinegrass (*Stipa spartea* Trin.).

Results and Discussion

Precipitation from September 1978 through March 1979 was approximately 16 cm above normal (31 cm), which resulted in a moisture storage surplus at the initiation of the research project in April, 1979. Precipitation during the first growing season after application appeared to be adequate or above normal. During the period of April to July, 1980, a 15-cm deficit in monthly precipitation was recorded. Thus, at the time when the warm-season grasses were actively growing, a potentially droughty condition occurred.

Relative Species Composition

Kentucky bluegrass and smooth brome constituted the largest percentage of the vegetation prior to treatment (April, 1979) (Fig. 1,2). Both species remained dominant on the control plots during the 2 years of the experiment. Kentucky bluegrass and smooth brome made up 39 and 46% respectively, of the total vegetation on the control plots in April and August, 1979, and 41 and 35% in May and September, 1980.

Applications of atrazine and glyphosate reduced the relative species composition of Kentucky bluegrass by 96 and 98% at the end of 1979 (Fig. 1). Relative species composition remained stable

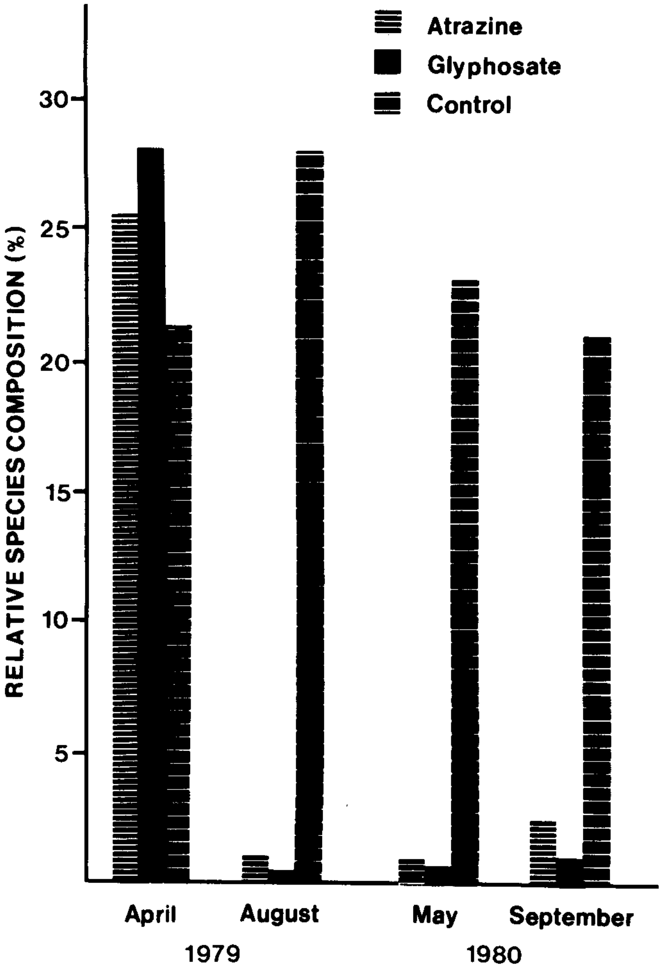

Fig. 1. *The effect of atrazine and glyphosate on relative species composition (%) trends for Kentucky bluegrass. The standard error of the mean (calculated from all observations across treatments) is 1.8, 1.7, 2.1 and 2.4 for April, August, 1979, and May, September, 1980, respectively.*

on control plots at 21 and 28% in April and August, 1979. Throughout 1980, Kentucky bluegrass on atrazine and glyphosate treated plots approximated the level determined for both treatments in August, 1979. During the second growing season, Kentucky bluegrass remained stable on the control plots (May, 23% and September, 21%). The apparent decrease in Kentucky bluegrass on the control plots from August 1979 (28%) to September 1980 (21%) indicated that a grazing rest for 2 years resulted in a small reduction of Kentucky bluegrass. However, both herbicide treatments, applied once in 1979, appeared to be effective in reducing Kentucky bluegrass and maintaining the supressesion for 2 growing seasons. The difference in Kentucky bluegrass suppression between the 2 herbicide treatments was minimal.

Late spring applications of atrazine or glyphosate were also effective in reducing smooth brome (Fig. 2). Smooth brome on the control, atrazine, and glyphosate treated plots was approximately equal in April 1979 (18, 17, and 17%, respectively). By August 1979, both atrazine and glyphosate had reduced smooth brome by 91 and 79%, as compared to the control. The late season decline of smooth brome in 1980 on both herbicide plots appeared to be an interaction of weather, seasonality and competition with warm-season species. Both herbicide treatments were equally effective in reducing and maintaining the lower levels of smooth brome. Results indicated that the 2 year grazing rest on control plots was not effective in reducing the relative species composition of smooth brome.

Smooth brome appeared to be more resistant than Kentucky bluegrass to either herbicide treatment (Fig. 1,2). Increases in

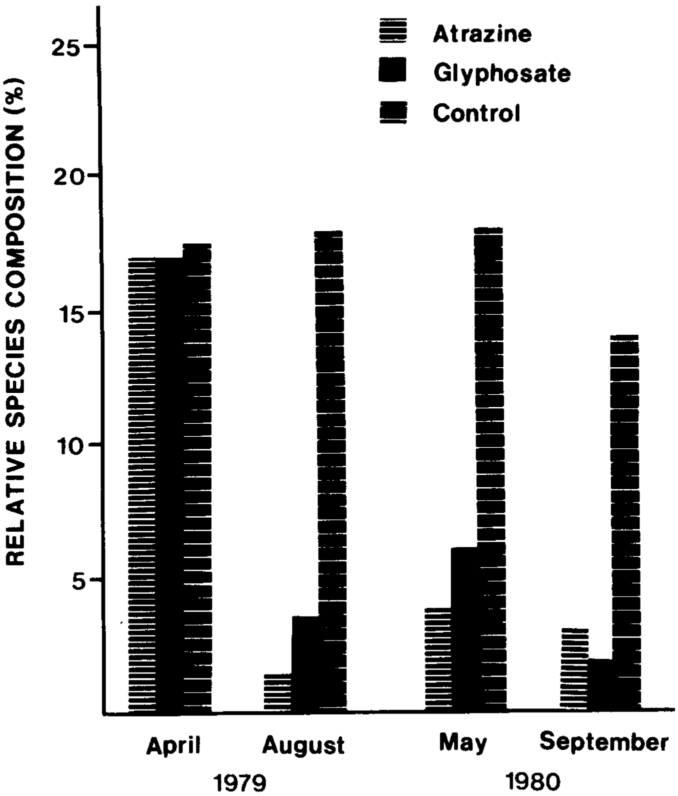

Fig. 2. *The effect of atrazine and glyphosate on relative species composition (%) trends for smooth brome. The standard error of the mean (calculated from all observations across treatments) is 3.2, 2.1, 1.6 and 1.2 for April, August, 1979 and May, September, 1980, respectively.*

application rates of both herbicides may be required to obtain larger decreases in smooth brome due to its apparent resistance. Although complete reductions of smooth brome and Kentucky bluegrass were not obtained with a single spring application of herbicide, it appeared that suppression of both was adequate to allow recovery of warm-season grasses.

Elimination or suppression of the cool-season grasses by selective herbicide treatment resulted in a corresponding increase in the native, warm-season, tall grass species, apparently due to reductions in competition (Fig. 1). Both atrazine and glyphosate increased warm-season grass species including big bluestem, indiangrass, switchgrass, and little bluegrass. The response of warm-season grasses to the 2 herbicide treatments was most evident by an increase in big bluestem. Percentages of big bluestem in August 1979 were 71 and 69% greater on atrazine and glyphosate treated plots than on control plots. Relative species composition of big bluestem exhibited a seasonal trend in 1980 due to sampling date; however, on both atrazine and glyphosate treatments it remained more than twice as large as on control plots.

The increase in big bluestem on control plots indicated that big bluestem responded to the 2-year grazing rest. However, the increase was minimal and was well below first-year levels on both herbicide treated plots.

There was a shift in the relative proportion of big bluestem, Kentucky bluegrass, and smooth brome during 1979 (Stroup and Stubbendieck 1983). However, during 1980 there was no significant change in the relative proportions indicating that the shift in species composition was rapid and stabilized quickly.

Herbage Yields

Total, Warm- and Cool-Season

The herbage yield in May 1979 on the control plots was larger than for the average of the herbicide treatments (Table 1). Warm-season herbage yields were not significantly different in May 1979. However, cool-season herbage yields were greater for control plots

Table 1. Independent orthogonal contrasts comparing the effect of atrazine (Atr) versus glyphosate (Gly) and the average effect of Atr and Gly treatments (Herb) versus control (Con) on herbage yields (kg/ha) of total, warm-season and cool-season grasses.

	Orthogonal contrasts					
	May 1979		Sept. 1979		Sept. 1980	
Species/treatment	Herb vs Con	Atr vs Gly	Herb vs Con	Atr vs Gly	Herb vs Con	Atr vs Gly
Total						
Atr		710		6106		4234
Gly		582		6147		4079
Herb	646		6126*[1]		4154*	
Con	1410*		3557		3269	
Warm-season						
Atr		237		5226		3685
Gly		227		5464		3192
Herb	232		5345*		3438*	
Con	258		1610		1858	
Cool-season						
Atr		264		9		74
Gly		157		154		56
Herb	210		82		65	
Con	785*		1097*		863*	

[1]*indicates significantly greater yield ($P<.05$) within a paired comparison.

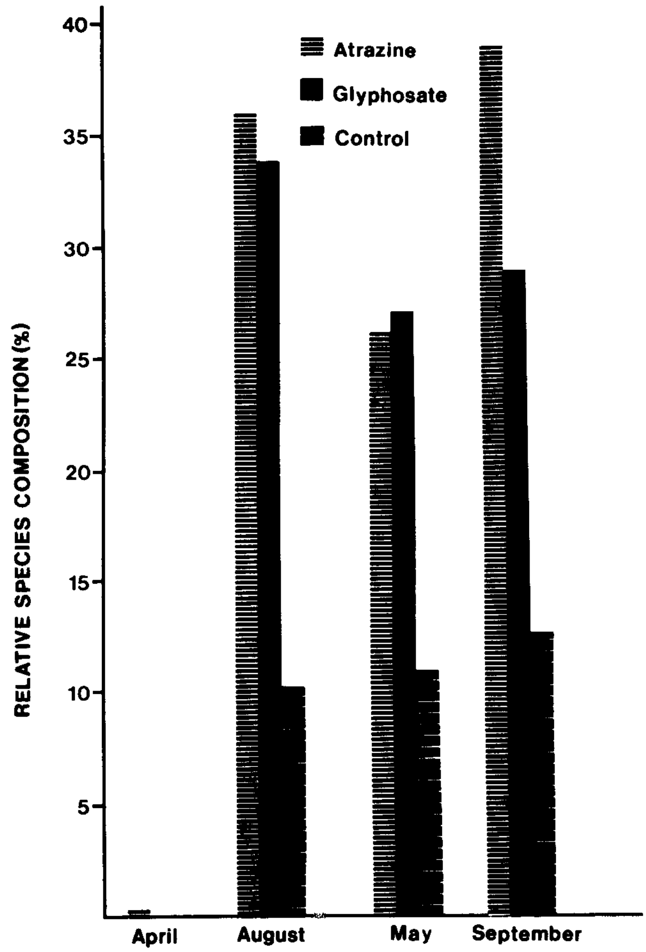

Fig. 3. *The effect of atrazine and glyphosate on relative species composition (%) for big bluestem. The standard error of the mean (calculated from all observations across treatments) is .04, 3.5, 3.9 and 3.3 for April, August, 1979 and May, September, 1980, respectively.*

Table 2. Independent orthogonal contrasts comparing the effect of atrazine (Atr) versus glyphosate (Gly) and the average effect of Atr and Gly treatments (Herb) versus control (Con) on herbage yields (kg/ha) of big bluestem, smooth brome and Kentucky bluegrass.

	Orthogonal contrasts					
	May 1979		Sept. 1979		Sept. 1980	
Species/ treatment	Herb vs Con	Atr vs Gly	Herb vs Con	Atr vs Gly	Herb vs Con	Atr vs Gly
Big bluestem						
Atr		111		3216		1782*[1]
Gly		95		2640		1344
Herb	103		2928*		1563*	
Con	92		490		655	
Smooth brome						
Atr		215		4		57
Gly		119		14		55
Herb	167		9		56	
Con	419*		760*		730*	
Kentucky bluegrass						
Atr		47		2		17
Gly		21		0		1
Herb	34		1		9	
Con	220*		319*		132*	

[1]*indicates significantly greater yield ($P<.05$) within a paired comparison.

than for herbicide treated plots. Total, warm- and cool-season herbage yields on atrazine plots were not different from glyphosate plots.

Total herbage yield in September 1979 for herbicide treatment was larger than for control plots (Table 1). Total herbage yield was not different between atrazine and glyphosate treatments. Warm-season herbage yield for herbicide treatments was greater than for control plots while cool-season yields were reduced. Cool-season and warm-season herbage yields on atrazine plots were not different from yields on glyphosate plots. These effects were maintained during the 1980 growing season.

The higher total and warm-season herbage yields in 1979 on both herbicide treatments as compared to September 1980 appeared to be an interaction between maturity and the environmental conditions during the 1980 growing season. The increase in warm-season herbage yield on the control during the study indicated that a grazing rest was beneficial. However, warm-season herbage yield on atrazine and glyphosate plots was 69 and 71% larger, respectively, than on control plots by September, 1979, emphasizing the difference in response time to these treatments.

Yield by Species

Herbage yields of big bluestem constituted the majority of the warm-season herbage yield throughout the experiment. Herbage yield of big bluestem on herbicide treated plots was not different from that on control plots in May, 1979 (Table 2). Smooth brome and Kentucky bluegrass herbage yield on herbicide treated plots was lower than on control plots. Herbage yields of big bluestem, smooth brome, and Kentucky bluegrass from atrazine-treated plots were not different from those on glyphosate plots.

Herbage yield of big bluestem on herbicide treatments was larger than on control plots in September, 1979 (Table 2). Big bluestem herbage yield on atrazine and glyphosate treatments was 85 and 81% larger, respectively, than on control plots. Herbage yield of big bluestem from glyphosate treatments was not different from atrazine treatments. However, herbage yield of big bluestem for atrazine treatments was larger than glyphosate treatments in September, 1980, with both exceeding the control. Possibly, the atrazine treatment enhanced the drought resistance of big bluestem. The effect of atrazine on drought resistance has been previously reported (Hyder et al. 1976). Smooth brome and Kentucky bluegrass herbage yields from herbicide treatments were less than from control plots and this was maintained during 1980. Recovery of warm-season remnants in this study supported observations made in 2 different years on 2 different sites in eastern Nebraska where herbicides were used to suppress cool-season vegetation (Samson and Moser 1982).

Summary

A single, late spring application of atrazine or glyphosate successfully stimulated a rapid recovery of warm-season grass remnants on overgrazed, native pasture in eastern Nebraska. Suppression of the cool-season, introduced dominants (Kentucky bluegrass and smooth brome) reduced competition and promoted warm-season species, primarily big bluestem. Dramatic changes in the proportion of warm-season vegetation occurred the year of treatment. Total quantity of forage produced increased and the period of optimum forage quality shifted from spring and fall to summer.

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