1982

Warm-season Grass Establishment with Atrazine

A. R. Martin
University of Nebraska-Lincoln

R. S. Moomaw
University of Nebraska, Concord

Kenneth P. Vogel
University of Nebraska-Lincoln, kvogel1@unl.edu

Warm-season Grass Establishment with Atrazine[1]

A. R. Martin, R. S. Moomaw, and K. P. Vogel[2]

ABSTRACT

Weed competition is a limiting factor in warm-season grass establishment often delaying the first forage harvest 2 or 3 years. Weed control with herbicides could reduce this competition resulting in more rapid grass establishment. Field experiments were conducted to evaluate the effect of atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine] on weed control, warm-season grass establishment, and forage yield during the seeding and following year.

Several warm-season grass species were spring seeded at locations having distinctly different soils. The soils involved were a Butler silty clay loam (Abruptic Argiaquoll) containing 3.8% organic matter and a pH of 5.2, a Crofton silty clay loam (Typic Ustorthent) containing 2.1% organic matter with a pH of 7.2 and a Nora silty clay loam (Udic Haplustoll) containing 2.8% organic matter and pH 5.8. Atrazine at various rates was applied preemergence shortly after grass seeding and at one site it was also applied the preceding fall. Weed control, grass establishment, and forage yield were measured the year of seeding and the following year.

Uncontrolled weeds during the year of seeding reduced stands and 1st year forage yields of big bluestem (*Andropogon gerardi* Vitman), indiangrass [*Sorghastrum nutans* (L.) Nash], sand lovegrass [*Eragrostis trichodes* (Nutt.) Wood], sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], and switchgrass (*Panicum virgatum* L.). Big bluestem and switchgrass tolerated preemergence atrazine applications of 3.4 kg/ha on the Butler soil. Big bluestem was less tolerant of atrazine than switchgrass on the Crofton soil. Some atrazine tolerance was present in indiangrass but not in sand lovegrass and sideoats grama. Seeding year forage yields of big bluestem and switchgrass were significantly increased by atrazine. Weed control during the seeding year sometimes resulted in higher forage yields the following year. Big bluestem and switchgrass can be readily established and produce substantial forage yields the year of seeding by using atrazine for weed control. This would make these grasses more attractive to farmers and ranchers.

***Additional index words:* *Andropogon gerardi* Vitman, *Bouteloua curtipendula* (Michx.) Torr., *Eragrostis trichodes* (Nutt.) Wood, Herbicide, *Panicum virgatum* L., Selective weed control, *Sorghastrum nutans* (L.) Nash.**

WEED competition is a serious limiting factor in the establishment of forage grasses from seed. Poor stands or complete stand failures may occur as a result of weed competition (4, 12). When weeds are controlled during the establishment phase of a new seeding excellent stands can be obtained (3, 12).

Warm-season perennial forage grasses are particularly slow to become established from seed, often requiring 2 to 4 years from seeding before they can be grazed or harvested for hay (18). This slowness and uncertainty of stand establishment deters many farmers and ranchers from seeding warm-season grasses. One of the major reasons for the slow establishment is weed competition (2, 16, 17, 18). Cool-season weed species are especially competitive (16).

Weed competition has reduced both forage and seed yield of grasses (2, 6, 13). Uncontrolled weeds reduced 2nd year forage yields of big bluestem (*Andropogon gerardi* Vitman) and indiangrass [*Sorghastrum nutans* (L.) Nash] 50 and 33%, respectively (2). Sideoats grama [Bouteloua curtipendula (Michx.) Torr.] seed yields were increased 10-fold with adequate weed control (13). Atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine] has been used successfully for weed control in established warm-season grasses (6). Atrazine and diuron [3-(3,4-dichlorophenyl)-1,1-dimethylurea] have been suggested for use on established warm-season grass seed production fields (5). Ethofumesate [(±)-2-ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuranyl methonesulfonate] has been used successfully to control annual bluegrass (*Poa annua* L.) in Italian ryegrass (*Lolium multiflorum* Lam.) seed fields (11). Post-emergence herbicides have been used effectively for weed control just prior to seeding and in new seedings of cool-season grasses (8, 10). The use of soil-applied herbicides for weed control in new grass seedings is a relatively new practice.

Lee (9, 12) investigated the use of activated charcoal, banded over the seeded row to protect grass seedlings from atrazine, diuron, simazine [2-chloro-4,6-bis(ethylamino)-*s*-triazine], and terbacil (3-*tert*-butyl-5-chloro-6-methyluracil). The activated carbon protected grass seedlings but usually resulted in poorer weed control in the carbon bands. McMurphy (14) evaluated propazine [2-chloro-4,6-bis(isopropylamino)-*s*-triazine], siduron [1-(2-methylcyclohexyl)-3-phenylurea], and norea [3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea] for use on new seedings of switchgrass (*Panicum virgatum* L.) big bluestem, indiangrass, and sideoats grama. Sideoats grama was severely damaged by all the herbicides evaluated. Norea damaged all four of the grasses. Propazine did not damage switchgrass or big bluestem while siduron damaged only sideoats grama. Ertel et al. (Ertel, J. S., E. J. Kinbacher, R. C. Shearman, and T. P. Riordan. 1979. Preemergence herbicide effect on establishment of blue grama turf. Agron. Abstr. p. 121.) evaluated several herbicides on new seedings of blue grama [*Bouteloua gracilis* (H.B.K.) Lag × Steud.] turf including atrazine, simazine, and benefin (*N*-butyl-*N*-ethyl-α,α,α-trifluoro-2,6-dinitro-*p*-toluidine) with benefin being the safest. Kinbacher et al. (Kinbacher, E. J., J. S. Ertel, R. S. Shearman, and T. P. Riordan. 1979. Effect of preemergence herbicides on the establishment of buffalograss turf. Agron. Abstr. p. 122.) found simazine promising for use on newly seeded buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] turf.

Research and commercial use on seed fields has demonstrated the safety of atrazine on established warm-season grasses. There has been evidence that *s*-triazine herbicides especially atrazine would be useful in establishing certain warm-season grasses from seed. With weed competition controlled, the time required for warm-season grasses to become established and productive would be reduced. This would make

[1] Published as Paper No. 6583, Journal Series, Nebraska Agric. Exp. Stn. Received 19 June 1981.

[2] Professor, Dep. of Agronomy, Univ. of Nebraska, Lincoln, NE 68583; Professor, Northeast Station, Univ. of Nebraska, Concord, NE 68728; and research agronomist, USDA, ARS and associate professor, Univ. of Nebraska, Lincoln, NE 68583, respectively.

the increased use of warm-season grasses more economical to the farmer and rancher.

Field studies were conducted at Concord and Mead, Nebr. from 1977 through 1979 to evaluate the use of atrazine on new seedings of several warm-season grasses. Experiments were designed to evaluate weed control, grass establishment and forage yield as influenced by atrazine during the seeding and following year.

MATERIALS AND METHODS

Concord Experiments. An experiment was initiated in 1977 on a Crofton silty clay loam (Typic Ustorthent) containing 33% clay, 2.1% organic matter, and having a pH of 7.2. After disking and harrowing for seedbed preparation, grass was seeded 28 April in 18 cm rows with a plot drill which was used for all experiments (15). Individual plots consisted of seven drilled rows 5.5 m long spaced 18 cm apart and were arranged in a randomized complete block design with four replications. Seed of 'Pathfinder' switchgrass, 'Holt' indiangrass, 'Trailway' sideoats grama, and 'Pawnee' big bluestem was planted at 465 PLS/m^2. Seed of big bluestem and indiangrass was processed on rubbing boards to remove awns and sterile florets to facilitate precise planting. Treatments consisted of atrazine applied preemergence at 0, 1.1, and 2.2 kg/ha on 29 April with and without handweeding. Handweeded plots were hoed as needed.

Stand establishment was determined in late June by taking four line transects per plot and counting the number of points out of 100 points at 5 cm intervals along the transect contacting a clump of grass. Visual weed control evaluations were made on 30 June. On 2 July plots were clipped above grass height with a mower and weeds were harvested and expressed as kg/ha of oven-dry material. Grass growth was excellent where weeds were controlled; however, yields were not taken until 1978. In early spring 1978, grass growth from the previous year was removed and 0.9 kg/ha atrazine was applied to the experimental site on 4 April. Forage yield was determined 16 Aug. 1978 by clipping a 0.6 m swath from the center of each plot with the yield expressed as kg/ha of oven-dry forage. Weed growth was removed and excluded from the forage yield. Forage yields were taken again on 29 Aug. 1979 and expressed as kg/ha of oven-dry material.

Another experiment was initiated in 1977 on a Nora silty clay loam (Udic Haplustoll) containing 34% clay, 2.8% organic matter, and having a pH of 5.8. The experimental design was a split block with time of atrazine applications as the main plots and four replications. Treatments consisted of atrazine applied either in the fall of 1977 or the spring of 1978 with and without handweeding. Fall atrazine application was made on 26 Sept. 1977 at 0, 1.7, and 3.4 kg/ha to plots 1.0 by 5.5 m. The entire area was rototilled 5 cm deep and harrowed before seeding grasses on 11 May 1978. Pathfinder switchgrass, Holt indiangrass, Trailway sideoats grama, and Pawnee big bluestem were seeded as described in the 1977 experiment. Spring atrazine applications were made on 13 May 1978 at 0, 1.1, and 2.2 kg/ha. Handweeded plots were hoed as needed. Grass stand was determined in late June as previously described. Weed growth was determined 6 July 1978 by hand clipping above grass height. Forage yields were determined as previously described on 6 and 7 November. Weed yields were also determined on 6 and 7 November in conjunction with forage harvest by hand separating weed plants in the harvest area from the cultivated grass growth.

Atrazine at 0.9 kg/ha was applied 4 Apr. 1979 to the entire

Table 1. Mean grass stand, forage and weed yields for four warm-season grasses seeded on a Crofton silty clay loam with a pH of 7.2 in 1977 as influenced by weed control at Concord, Nebr. from 1977 through 1979.

Grass	Atrazine	Grass stand†‡	Oven-dry top-growth: Weeds 1977	Oven-dry top-growth: Forage 1978	Oven-dry top-growth: Forage 1979
	kg/ha	%	kg/ha		
Big bluestem	0	56 bc	930 a	5,020 c	6,830 a
	0 + handweed	78 a	0 b	7,530 ab	6,340 a
	1.1	45 cd	270 b	6,630 bc	7,930 a
	1.1 + handweed	60 b	0 b	9,390 a	8,000 a
	2.2	38 d	0 b	8,530 ab	7,190 a
	2.2 + handweed	44 cd	0 b	9,650 a	7,930 a
Indiangrass	0	32 b	1,150 a	5,800 b	8,980 ab
	0 + handweed	61 a	0 b	9,320 a	10,100 a
	1.1	14 c	200 b	2,350 c	7,350 ab
	1.1 + handweed	9 c	0 b	6,700 b	6,720 b
	2.2	2 c	0 b	1,210 c	3,560 c
	2.2 + handweed	2 c	0 b	1,210 c	4,210 bc
Sideoats grama	0	24 b	1,480 a	1,030 b	6,070 ab
	0 + handweed	50 a	0 a	6,430 a	6,770 a
	1.1	10 c	550 b	810 b	3,580 bcd
	1.1 + handweed	14 bc	0 c	6,030 a	5,000 abc
	2.2	2 c	0 c	990 b	2,690 cd
	2.2 + handweed	2 c	0 c	1,080 b	1,860 d
Switchgrass	0	4 a	1,980 a	3,990 c	8,470 b
	0 + handweed	12 a	0 b	12,590 a	12,570 a
	1.1	7 a	290 b	4,700	10,010 ab
	1.1 + handweed	9 a	0 b	10,040 b	9,770 ab
	2.2	10 a	10 b	9,090 b	9,390 b
	2.2 + handweed	8 a	0 b	10,570 ab	10,370 ab

† Based on a grass stand of a plant every 5 cm of row.
‡ Numbers within columns for individual grass species followed by the same letter are not different at the 5% level of probability using Duncan's Multiple Range Test. In the combined analysis the species and species × atrazine rate effects on grass stand and forage yield were significant at the 0.05 level.

experimental area. This treatment provided partial weed control. Weed growth was hand separated and excluded from the forage yields, which were determined on 29 and 30 Aug. 1979.

Mead Experiment. An experiment was initiated in 1978 on a Butler silty clay loam (Abruptic Argiaquoll) containing 3.8% organic matter and a pH of 5.5. The experimental design was a randomized complete block with a split-split plot treatment arrangement and four replications. Grass species were main plots, atrazine rates were subplots and handweeding vs. no weeding were sub-subplots. After disking and harrowing for seedbed preparation, grasses were seeded on 17 May 1978. Individual plots were seven 18 cm rows wide and 4.6 m long. Seed of Pathfinder switchgrass, Hold indiangrass, Trailway sideoats grama, Pawnee big bluestem, and 'Nebr 27' sand lovegrass was seeded at 400 PLS/m^2. Seed of big bluestem and indiangrass was processed to remove awns and sterile florets. Atrazine was applied at 0, 1.1, 2.2, and 3.4 kg/ha on 19 May 1978. Sub-subplots were handweeded on 27 and 28 June 1978. Stand establishment in the handweeded plots was determined on 28 June 1978. Grass seedlings were counted in 1 m sections of two rows and expressed as seedlings/2 m of row.

Forage and weed yields in 1978 were harvested on two replications of the main plots on 6 and 14 Sept. 1978. Plots were mowed at a 5 cm height and yields expressed as kg/ha of oven-dry matter. The entire experimental area was treated with DCPA (dimethyl tetrachloroterephthalate) at 13.4 kg/ha on 1 May 1979, and with 2,4-D [(2,4-dichlorophenoxy) acetic acid] amine at 1.1 kg/ha on 29 June 1979 to control weeds in plots with thin grass stands. The area

Table 2. Mean grass stand, forage and weed yields for four warm-season grasses seeded on a Nora silty clay loam with a pH of 5.8 as influenced by weed control at Concord, Nebr. in 1978 and 1979.

				Oven-dry top-growth			
				Weeds		Forage	
Grass	Atrazine	Time of atrazine application	Grass stand†‡	7-6-78	11-6, 7-78	1978	1979
	kg/ha		%	kg/ha			
Big bluestem	0	Fall (F)	60 a	3,000 a	2,130 a	2,420 b	6,410 a
	0 + handweed	F	70 a	0 b	0 d	3,830 a	6,880 a
	1.7	F	65 a	530 b	1,110 b	2,200 b	6,320 a
	1.7 + handweed	F	68 a	0 b	0 d	2,910 ab	7,210 a
	3.4	F	41 b	30 b	290 c	2,910 b	7,240 a
	3.4 + handweed	F	39 b	0 b	0 d	2,690 b	6,920 a
	0	Spring (S)	60 ab	3,000 a	2,130 a	2,420 b	6,410 a
	0 + handweed	S	70 a	0 b	0 c	3,830 a	6,880 a
	1.1	S	67 ab	520 b	510 b	2,850 ab	6,790 a
	1.1 + handweed	S	64 ab	0 b	0 c	3,320 b	7,530 a
	2.2	S	54 bc	190 b	690 b	2,580 b	6,940 a
	2.2 + handweed	S	46 c	0 b	0 c	2,930 ab	8,020 a
Indiangrass	0	F	28 ab	1,900 a	3,420 a	290 b	340 b
	0 + handweed	F	37 a	0 b	0 d	1,570 a	8,650 a
	1.7	F	11 c	220 b	760 c	270 b	1,010 b
	1.7 + handweed	F	16 bc	0 b	0 d	540 b	1,790 b
	3.4	F	6 c	20 b	1,530 b	110 b	290 b
	3.4 + handweed	F	7 c	0 b	0 d	110 b	610 b
	0	S	28 abc	1,770 a	3,430 a	290 b	340 c
	0 + handweed	S	37 a	0 b	0 c	1,570 a	8,650 a
	1.1	S	22 bcd	410 b	1,750 b	1,320 ab	990 c
	1.1 + handweed	S	34 ab	0 b	0 c	1,140 ab	9,270 a
	2.2	S	13 d	90 b	1,740 b	490 ab	2,780 b
	2.2 + handweed	S	14 cd	0 b	0 c	490 ab	3,540 b
Side-oats grama	0	F	24 b	1,280 a	2,950 a	520 b	2,490 b
	0 + handweed	F	44 a	0 b	0 c	2,930 a	7,800 a
	1.7	F	19 bc	650 ab	1,660 b	1,010 b	900 bc
	1.7 + handweed	F	9 cd	0 b	0 c	740 b	1,660 bc
	3.4	F	1 d	70 b	1,150 b	290 b	160 c
	3.4 + handweed	F	3 d	0 b	0 c	380 b	180 c
	0	S	24 b	1,280 a	2,950 a	520 b	2,490 b
	0 + handweed	S	44 a	0 b	0 d	2,930 a	7,800 a
	1.1	S	25 b	300 b	2,090 b	1,430 b	2,620 b
	1.1 + handweed	S	45 a	0 b	0 d	3,410 a	6,430 a
	2.2	S	11 c	90 b	1,000 c	1,120 b	1,590 bc
	2.2 + handweed	S	6 d	0 b	0 d	720 b	450 c
Switchgrass	0	F	58 b	910 a	0 a	4,190 b	1,140 a
	0 + handweed	F	76 a	0 a	0 a	5,350 a	10,710 a
	1.7	F	66 ab	130 a	0 a	5,800 a	6,790 b
	1.7 + handweed	F	71 ab	0 a	0 a	5,150 ab	7,530 b
	3.4	F	64 ab	0 a	0 a	6,030 a	6,940 b
	3.4 + handweed	F	57 b	0 a	0 a	5,960 a	8,020 b
	0	S	58 a	910 ab	0 b	4,190 d	11,400 a
	0 + handweed	S	76 a	0 b	0 b	5,350 bc	10,710 ab
	1.1	S	60 b	960 a	1,570 a	4,390 cd	7,100 c
	1.1 + handweed	S	66 ab	0 b	0 b	5,850 ab	11,130 ab
	2.2	S	53 b	100 ab	0 b	6,450 a	12,570 a
	2.2 + handweed	S	58 b	0 b	0 b	6,790 a	10,330 b

† Based on one or more grass plants per 5 cm of row being a 100% stand.
‡ Numbers within columns for individual grass species and time of herbicide application followed by the same letter are not different at the 5% level of probability using Duncan's Multiple Range Test. In the combined analysis the species and species × atrazine rate effects on grass stand and forage yield were significant at the 0.05 level.

was fertilized on 14 May 1979 with 112 kg/ha N as NH_4NO_3. The experimental area was handweeded prior to harvest. Grasses were harvested on 20 Aug. 1979 by mowing at a 5 cm height and yields expressed as kg/ha of oven-dry matter. Stand counts in 1979 were determined by placing a metal grid containing 25 squares each 15 by 15 cm over the center five rows of each plot. The number of squares containing a grass plant or portion of a plant were counted and the numbers multiplied by 4 to obtain percent stand.

Results were analyzed using standard statistical procedures. Weed yields from sand lovegrass plots at Mead in 1978 were excluded from the analysis of variance because weed yields from only one replication were available. Weed yields in the other replication were not determined since there was no harvestable forage in any of these plots treated with atrazine.

RESULTS AND DISCUSSION

Weed Control. Green foxtail [*Setaria viridis* (L.) Beauv.] and redroot pigweed (*Amaranthus retroflexus* L.), were the principal weed species at both Concord and Mead. Weed growth tended to be greater at Mead than at Concord in atrazine treated as well as the untreated plots (Tables 1, 2, and 3). Greater rainfall, soil organic matter and soil weed seed numbers at Mead all contributed to the greater weed growth.

Table 3. Mean stands, forage and weed yields for five warm-season grasses seeded in 1978 as influenced by weed control at Mead, Nebr. in 1978 and 1979.

			1978					1979					
			Oven-dry top-growth								Oven-dry top-growth		
			Forage yield†			Weed yield		% Stand†§			Forage yield		
Grass	Atrazine	Grass seedlings/ 2 m row†	Weeded	Not weeded	Avg.	Weeded	Not weeded	Weeded	Not weeded	Avg.	Weeded	Not weeded	Avg.
	kg/ha			kg/ha					%			kg/ha	
Big bluestem	0	50	4,440	760	2,600	1,080	2,330	98	97	98	9,540	7,100	8,310
	1.1	48	5,470	3,850	4,660	2,110	5,940	93	99	96	10,680	10,040	10,370
	2.2	59	2,550	7,170	4,860	4,320	760	95	95	95	10,600	9,120	9,860
	3.4	44	6,770	4,300	5,530	780	690	93	96	95	11,330	8,670	10,010
	Avg.	50	4,820	4,030	4,440	2,070	2,430	95	97	96	10,550	8,740	9,650
Indiangrass	0	43	3,670	50	1,860	2,200	16,260	99	62	81	7,330	3,610	5,470
	1.1	27	1,930	1,250	1,590	2,640	1,640	84	68	76	7,280	4,030	5,670
	2.2	16	1,230	90	670	670	8,800	71	59	65	5,290	3,970	4,640
	3.4	6	990	580	780	2,730	4,100	52	40	46	4,010	2,200	3,110
	Avg.	23	1,950	490	1,230	1,570	7,700	77	57	67	5,980	3,450	4,730
Sand lovegrass¶	0	35	3,740	N	1,880	2,400	13,370	71	51	61	4,860	2,530	3,700
	1.1	20	1,660	N	830	3,500	11,470	42	10	26	2,370	870	1,640
	2.2	1	N‡	N	N	1,590	2,930	1	0	1	130	430	290
	3.4	0	N	N	N	2,600	3,050	1	0	1	90	20	70
	Avg.	14	1,340	N	670	2,520	7,705	29	15	22	1,860	960	1,410
Side-oats grama	0	46	4,440	1,250	2,850	3,000	9,500	88	72	80	9,100	5,560	7,320
	1.1	6	990	990	990	2,170	3,090	47	30	39	2,580	1,800	2,200
	2.2	1	760	490	630	2,150	6,700	6	16	11	1,120	780	960
	3.4	0	310	220	270	2,620	1,390	12	3	8	310	600	470
	Avg.	13	1,640	740	1,190	2,499	5,170	38	30	34	3,270	2,200	2,730
Switch-grass	0	44	8,650	N	4,320	4,170	16,040	90	65	78	11,650	9,050	10,350
	1.1	39	9,090	6,050	7,570	1,900	5,400	97	97	97	14,000	13,400	13,710
	2.2	45	8,020	5,380	6,700	520	5,200	96	94	95	12,210	11,290	11,760
	3.4	51	9,180	8,420	8,800	360	540	93	93	93	12,860	13,330	13,100
	Avg.	45	8,740	5,000	6,880	1,740	3,200	94	87	91	12,680	11,760	12,230
Among grass		12		760		1,838			7			1,120	
Atrazine rates within a grass		17		2,220		2,802			14			1,700	
Weeding treatment for a grass at a specific atrazine rate				450		6,972			18			2,780	
Atrazine rates for a grass with with the same weeding treatment				3,270		11,412			19			2,600	

† L.S.D. P = 0.05 for the appropriate mean comparisons (in parenthesis) are listed below their corresponding treatment means. For example to compare 1978 grass stands among grasses the L.S.D. = 12 while the L.S.D. for atrazine rates within a grass is 17.
‡ N indicates quantity too small to harvest.
§ Based on one or more grass plants per 225 cm^2 being a 100% stand.
¶ L.S.D. values are not applicable to sand lovegrass because sand lovegrass was excluded from weed yield ANOVA.

Atrazine provided less complete weed control at Mead than at Concord.

Soil pH and organic matter both have a strong influence on atrazine activity (7). Atrazine activity and persistence is increased at higher pH levels (1). Soil organic matter adsorbs atrazine reducing its activity (7). This effect of carbon and organic matter on atrazine activity has been utilized by applying bands of activated carbon over the crop row to protect crops from atrazine injury (9). The effect of soil pH and organic matter on atrazine activity has an influence on suggested use patterns (Ciba-Geigy Corp., 1982. Agricultural Division Sample Labels. p. 1–17).

Soil organic matter and pH differences would contribute to lesser atrazine activity and reduced weed control at the Mead location than either of the Concord sites. The 2.2 kg/ha atrazine application in the 1977 Concord experiment provided better weed control than in the 1978 experiment. Greater soil pH (7.2 vs. 5.8) and lower soil organic matter (2.1% vs. 2.8%) probably contributed to greater atrazine activity on the 1977 site and therefore better weed control. Weed control with the 3.4 kg/ha atrazine rate in the fall at Concord was comparable to the 2.2 kg/ha rate applied in the spring (Table 2). The 2.2 kg/ha atrazine application provided almost complete weed control at Concord in 1977 but in the other experiments some weed growth and therefore competition with the grass occurred even at the highest rates of atrazine used.

Grass Stand. There was a significant grass by atrazine rate interaction on grass stand in these studies (Tables 1, 2, and 3). Poor stands of switchgrass were obtained at Concord in 1977 because the seed was old and had poor seedling vigor. Examination of the species response to atrazine showed that switchgrass was tolerant of atrazine at the rates used at Concord in 1977 and Mead in 1978 as indicated by the stands in the handweeded plots (Tables 1 and 3). There was a switchgrass stand reduction at Concord with the 2.2 kg/ha atrazine application in the spring of 1978 (Table 2). Spring atrazine applications at 2.2 kg/ha caused a big bluestem stand reduction in both Concord experiments, but not at Mead where the soil pH was lower and organic matter content higher. This suggests big bluestem is somewhat less tolerant of atrazine than switchgrass. Indiangrass showed some tolerance to atrazine, but stand reductions were substantial even at low atrazine rates at all three sites. Sideoats grama was more sensitive to atrazine than indiangrass, and sand lovegrass was the most sensitive of the five species.

Weed competition was a significant factor in grass establishment. Handweeding in the absence of atrazine resulted in improved stands the year of seeding especially with indiangrass and sideoats grama (Tables 1 and 2). Big bluestem and switchgrass stands the year of seeding suffered less from weed competition than the other grasses. Stands improved markedly between 1978 and 1979 at Mead with all of the grasses (Table 3). Stands of indiangrass, sand lovegrass, and sideoats grama the 2nd year continued to reflect poor weed control during the seeding year as indicated by the 1979 stand of weeded compared with non-weeded plots (Table 3). Big bluestem and switchgrass stands were quite good the 2nd year even without weed control, indicating that these species are better weed competitors than the other grasses.

Forage Yield. Handweeding without atrazine during the year of seeding caused a dramatic increase in yield of all the grasses at all locations illustrating the detrimental effect of weed competition on grass production (Tables 1, 2, and 3). None of the grasses produced a harvestable yield during the year of seeding without weed control. With weed control, big bluestem and switchgrass produced forage yields of 3,830 and 5,350 kg/ha, respectively at Concord in 1978 and 4,440 and 8,650 kg/ha, respectively at Mead the year of seeding (Tables 2 and 3). Forage yields of big bluestem and switchgrass treated with atrazine were equal and usually significantly greater than the plots not treated with atrazine the year of seeding. Even though the low rates of atrazine reduced indiangrass stands, forage yields the year of seeding were equal to the no weed control treatments. Thus, the benefit of weed control offset the effect of stand loss due to low rates of atrazine. Sideoats grama and sand lovegrass were more sensitive to atrazine and 1st year yields tended to be reduced even at low rates of atrazine.

Second and third year forage yields tended to be higher, though not in all cases, where weed control as handweeding was utilized the year of seeding. Weed control with atrazine the year of seeding gave this same response during the 2nd and 3rd year with big bluestem and switchgrass.

Atrazine was applied preemergence at 2.2 kg/ha to 23 different switchgrass cultivars and 10 big and sand bluestem cultivars in a yield test at Mead, Nebr. in 1980 without adverse visual affects. This indicates the atrazine tolerance of these grasses is acceptable among the cultivars currently available.

LITERATURE CITED

1. Best, J. A., and J. B. Weber. 1974. Disappearance of *s*-triazines as affected by soil pH using a balance sheet approach. Weed Sci. 22:364–373.
2. Bryan, G. G., and W. E. McMurphy. 1968. Competition and fertilization as influences on grass seedlings. J. Range Manage. 21:98–101.
3. Cox, M. L., and M. K. McCarty. 1958. Some factors affecting establishment of desirable forage plants in weedy bluegrass pastures of eastern Nebraska. J. Range Manage. 11:159–164.
4. Fermanian, T. W., W. W. Haffine, and R. D. Morrison. 1980. Preemergence weed control in seeded bermudagrass stands. Agron. J. 72:803–805.
5. Furrer, J. D., A. R. Martin, F. W. Roeth, R. S. Moomaw, R. G. Wilson, and G. A. Wicks. 1981. A 1981 Guide for Herbicide Use in Nebraska. EC 81–130, Univ. of Nebraska, Lincoln. p. 16.
6. Houstan, W. R. 1977. Species susceptibility to atrazine herbicide on shortgrass range. J. Range Manage. 30:50–52.
7. LeBaron, H. M. 1970. Ways and means to influence the activity and the persistence of triazine herbicides in soils. Res. Rev. 32:311–353.
8. Lee, W. O. 1965. Herbicides in seedbed preparation for the establishment of grass seed fields. Weeds 13:293–297.
9. ———. 1973. Clean grass seed crops established with activated carbon bands and herbicides. Weed Sci. 21:537–541.
10. ———. 1975a. Wild oat control in Kentucky bluegrass and perennial ryegrass. Weed Sci. 23:525–528.
11. ———. 1975b. Winter annual grass weed control in Italian ryegrass with ethofumesate. Weed Sci. 25:252–255.
12. ———. 1978. Volunteer Kentucky bluegrass (*Poa pratensis*) control in Kentucky bluegrass seed fields. Weed Sci. 26:675–678.
13. McCarty, M. K., L. C. Newell, C. J. Scifres, and J. E. Congrove. 1967. Weed control in seed fields of side-oats grama. Weeds 15:171–174.
14. McMurphy, W. E. 1969. Pre-emergence herbicides for seeding range grasses. J. Range Manage. 22:427–429.
15. Vogel, K. P. 1978. A simple method of converting rangeland drills to experimental plot seeders. J. Range Manage. 31:235–237.
16. Warnes, D. D. 1966. Warm season grasses for tomorrow. Nebr. Farm, Ranch and Home Quar. 18:20–21.
17. ———, and L. C. Newell. 1969. Establishment and yield responses of warm-season grass strains to fertilization. J. Range Manage. 22:235–240.
18. ———, ———, and W. J. Moline. 1971. Performance evaluation of some warm-season prairie grasses in Nebraska environments. Nebr. Exp. Stn. Res. Bull. 241.