RESPONSE OF VARIOUS OLD WORLD BLUESTEM
CULTIVARS TO THREE S-TRIAZINE
HERBICIDES

By

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CHAPTER I

INTRODUCTION

If maximum production is to be obtained on our grasslands, unproductive forage species should be replaced by more productive ones. Certain cultivars of Old World bluestem grasses have the potential of greatly increasing both the production and carrying capacity of our grasslands. These grasses are vigorous plants which are persistent under grazing, drought tolerant, and winter-hardy.

Forage grasses are often slow to become established from seed. Native warm season grasses often require from 2 to 4 years after seeding before they can be grazed or harvested for hay. This deters many farmers and ranchers from seeding warm season grasses. One of the major problems is weed competition. Complete stand failures or poor stands may occur as a result of weed competition. In order to insure successful establishment of seedling stands, it is necessary to control both annual grasses and broadleaf weeds, without injuring desirable grass seedlings.

Postemergence herbicides such as 2,4-D [(2,4-dichlorophenoxy) acetic acid] have been used effectively for broadleaf weed control in seedling stands. However, annual grasses, also a common weed problem in grasslands, are not controlled with 2,4-D. Some triazine herbicides have shown promise of giving selective weed control in seedling establishment of some warm season grasses. The triazines are selective herbicides which are widely used to control annual grasses and broadleaf weeds. The triazines may be applied both postemergence and preemergence. Two of the triazines, atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine] and simazine [2-chloro-4,6-bis(ethylamino)-s-triazine], are currently labeled for use on established pastures and rangelands.

The objective of this study was to evaluate three s-triazine herbicides at three rates to determine if weeds could be selectively controlled in establishment of various Old World bluestem cultivars.

CHAPTER II

LITERATURE REVIEW

History and Use of Old World Bluestems

The Old World bluestems are also known as Asiatic bluestems (1). They are characterized as warm-season bunch grasses of tropical and sub-tropical affinity. Some members are important range and pasture plants (5). Various cultivars of Old World bluestems will fit into many integrated forage systems with grasses such as weeping lovegrass [*Eragrostis curvula* (Schrad.) Nees], bermudagrass [*Cynodon dactylon* (L.) Pers.], fescue [*Festuca* spp.], and native grass and may be useful in extending the forage quality calendar of our present pasture systems in some areas, if managed properly, well into late summer and fall (1). Most forage species decline in both production and quality during the late summer and fall, whereas some Old World bluestem types have their greatest growth rate potential at this time (1, 31). There are many types of Old World bluestems of apparent agronomic value (14). These grasses have acquired a wide range of adaptations. Some are highly productive, others are of low quality. Most lack winter hardiness, however, some are hardy as far north as the Dakotas. Ecologically, most of the forms are similar in that they appear to be best fitted to some stage of secondary succession. They do not behave as climax plants but tend rather to increase and thrive under grazing and other disturbances. They reproduce freely by seed, tending to be somewhat weedy, and as a whole are easily established in plantings (14). Drought resistance, productivity, high forage quality, winter hardiness, disease resistance, agressive seedling establishment, and other desirable qualities are found in the group (14).

There are currently three cultivars of primary importance in Oklahoma. 'Caucasian' [*Bothriochloa caucasica* (Trin.) C. E. Hubb] the first Old World bluestem to come into use during the 1930's. It was introduced from Russia in 1929 and evaluated by the Soil Conservation Service. The grass has consistently yielded greater forage yields than other commercially available cultivars of Old World bluestem. 'Plains' [*Bothriochloa ischaemum* (L.) Keng var. *ischaemum*] was the second cultivar to be used in Oklahoma. It was developed at the Oklahoma Agricultural Experiment Station by J. R. Harlan in 1963, and released by Taliaferro et al. in 1972 jointly with the Oklahoma Agricultural Experiment Station and the Plant Science Research Division, U.S. Department of Agriculture. This variety is a composite of 30 similar grasses from six different Asian countries (1, 30, 31). Plains combines attributes of good productivity, aggressiveness, persistence, and drought tolerance. The third cultivar, 'WW-Spar' [*Bothriochloa ischaemum* (L.) Keng var. *ischaemum*] is one of the components of Plains. It was selected for better production under dryland conditions of western Oklahoma. WW-Spar was released in 1981 by the USDA-ARS and the Oklahoma Agricultural Experiment Station[1].

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[1] Dewalt, C. USDA, Woodward, OK. Personal communication.

Competition with Seedling Grasses

Weed competition can be a limiting factor in establishment of both introduced and native grasses from seed. As a result of weed competition, poor stands or complete stand failures may occur (12, 21). Competition occurs at all times among plants of the same species as well as those of different species (10). Weaver and Clements (33) stated that competition always occurs where two or more plants make demands for light, nutrients, or water in excess of the supply. Competition is essentially a decrease in the amount of water, nutrients, or light available for each individual. Klingman (16) stated that the production of one pound of weeds will reduce production of more desirable plants by an equal amount. Lee (19) estimated 15 to 20 percent of the new grass seedings in western Oregon are plowed up because of weed competition. He found that weed competition in new grass seedings often causes severe retardations and weakening of the crop plants. The stand may be lost or it may take several years before plants are hardy enough to withstand an application of herbicide for weed control. He also found that even when a good stand resulted, seed production during the first years could frequently be lost due to weed infestations. Yield and seed quality was often so low that financial return was greatly reduced by weed competition. He noted that in a thin stand of grass without competition from weeds, plants soon filled the vacant spots and made a solid row. Bryan and McMurphy (3) also found weed competition to severely retard and weaken desirable grass plants. In their study, weed competition was primarily crabgrass [Digitaria *sanguinalis* (L.) Scop. # 2 DIGSA)] in a planting of an experimental Asiatic bluestem cultivar designated as "M" blend. Forage yields of all species were reduced 28 to 70 percent by the second year as compared to the production in the weed free plots. They concluded it was necessary to reduce weed competition in order that maximum yields could be achieved from native and introduced species. According to Hull et al. (15) it is necessary to establish a firm seedbed free of weed competition in order to obtain maximum seedling establishment. Where weeds are effectively controlled with herbicides during the establishment period, excellent stands of desirable grasses were obtained (8, 19, 21).

Establishment of improved forage species in weedy annual grass infested rangeland is also a problem. Seeding of rangelands without some type of land preparation or grazing management is often a failure because of competition from the resident annuals (24, 27). The annual bromes such as cheat [*Bromus secalinus* L. # BROSE] and downy brome [*Bromus tectorum* L. # BROTE] use much of the available winter and spring moisture before the desirable forage grasses begin growth in the spring (6).

Use of Herbicides

The phenoxy herbicide, 2,4-D, is a postemergence herbicide commonly used in establishing pastures and rangelands to control annual and perennial broadleaf weeds with little if any effect on grasses (2).

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[2] WSSA-approved computer code from Important Weeds of the World, 3rd ed. Available from WSSA, 309 West Clark St., Champaign, IL 61820

Postemergence applications of 2,4-D have also been effectively used in establishment of new seedings of cool season grasses (19, 20). Postemergence applications with residual herbicide such as atrazine are not always effective against weeds which have already emerged (9, 17). However, Burnside and Wicks (4) noted that postemergence applications of atrazine were effective against some grassy weeds. Although chemical control is often very effective, it is seldom completely successful. This may be a result of poor timing of herbicide application (34). The herbicide must be in the soil at the time of seed germination for adequate weed control.

Preemergence applications of the s-triazines have been shown to have potential for selective control of weeds in grass crops (4, 11, 22). The selective control of the triazine herbicides may be due to an alteration in the receptor site within the photosynthetic apparatus, as well as differential rates of degradation within the various plant species (32). Resistant species rapidly degrade triazine herbicides whereas susceptible species slowly degraded the herbicides. Ryan (28) in 1970 first reported resistance to atrazine in the weed Senecio vulgaris L. At rates used for selective weed control, the s-triazine can remain active in the soil for several months (17, 18). Preemergence herbicides for use at the time of seeding have long been available for many cultivated crops. In new grass seedings the use of soil-applied herbicides is a relatively new practice. Annual weed control in most soils following applications of atrazine provide better results than other methods of application when sufficient rainfall occurs within the first week or two (4). From the standpoint of the best or most complete weed control, preemergence applications of atrazine or other chloro-triazine herbicides would normally be the preferred method (18). According to Evans et al. (11) atrazine applied at 1.1 kg/ha was the most promising treatment with respect to three essential characteristics: length of activity, spectrum of weed control, and relative pre-and-postemergence phytoxicity. In the studies conducted by Evans et al., atrazine at 1.1 kg/ha controlled an average of 91% of downy brome, compared to an average of 73% control by simazine. Chamberlain et al., (6) have evaluated some herbicides on the control of Bromus species in the western states and northern Great Plains and found that the most consistent and best control was with atrazine. Yields of desirable warm season forage frequently doubled and in some cases tripled the first grazing season after application of atrazine. Chamberlain's studies showed that injury to established forage grasses with atrazine appeared to be greater from spring than from fall applied herbicide treatment. However, according to Morrow et al. (26), forage grasses apparently are able to recover from herbicide injury rapidly and with the reduced competition, total season production will increase.

In 1969, McMurphy (25) worked with preemergence herbicides for seedling establishment of range grasses. He found propazine [2-chloro-4,6-bis(isopropylamino)-s-triazine] to be a promising preemergence herbicide from the standpoint of seedling survival. Propazine gave complete control of broadleaf species but only partially reduced crab-grass competition. In addition to propazine, he evaluated siduron [1-(2-methylcyclohexyl)-3-phenylurea], and norea [3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea] for use in establishing switch-grass [Panicum virgatum L.], big bluestem [Andropogon geradii Vitman], indiangrass [Sorghastrum nutans (L.) Nash ex Small], several Old World bluestem cultivars, and sideoats grama [Bouteloua curtipendula (Michx.) Torr.]. Sideoats grama was damaged by all preemergence herbicide applications tested. Norea damaged all grass species tested, and siduron caused stand reductions of Old World bluestem cultivars. There were no apparent retarding effects by propazine on the germination and growth of switchgrass and Old World bluestem cultivars. A 2.2 kg/ha rate of propazine has been described as adequate for the control of annual grasses (29). According to Cornforth (7), preemergence applications of propazine signficantly reduced the number of weeds, and annual grass infestation is greatly affected by the presence or absence of the herbicide. Work done by the Forest Research Institute (13) revealed that the safest treatment that gives effective control of most weeds is to apply propazine at 1.1 kg/ha at seeding. Some leaf tip-burn appeared three weeks after emergence but did not affect survival. According to McCall (23) propazine appeared to be the least phytotoxic of the herbicides which he investigated. He noted that propazine had a detrimental effect on the cool season grasses: smooth bromegrass [Bromus inermis Leyss.], crested wheatgrass [Agropyron desertorum (Fisch. ex Link) Schult.], Kentucky 31 fescue [Festuca arundinacea (Schreb.)], and the cereals, wheat and rye.

CHAPTER III

METHODS AND MATERIALS

Field experiments were conducted during 1982 and 1983 to determine the selectivity of preemergence applications of three triazine herbicides to a number of Old World bluestem cultivars. Two cultivars of Old World bluestems 'Plains' and 'Caucasian' were evaluated in separate experiments at El Reno in 1982 and 1983 and at Stillwater in 1983. Also in 1983, five cultivars of Old World bluestems: 'WW-Spar', Caucasian and three experimental cultivars; 'WW-517' (selection of H-blend) [*Bothriochloa intermedia* (R. Br.) A. Camus var. *indica*], 'WW-535' [*Bothriochloa ischaemum* (L.) Keng var. *ischaemum*], and 'WW-857' [*Bothriochloa intermedia* (R. Br.) A. Camus var. *montana*] were evaluated in a split-plot experiment at Woodward. All herbicide applications were made with a hand-held carbon dioxide sprayer equipped with fan nozzles. The carrier volume was 187 l/ha and the pressure was 1.6 kg/cm^2. All herbicide treatments were applied preemergence on the day of planting. Rainfall data for the experiments are listed in Table 1.

El Reno and Stillwater Locations

Experimental design of the six field experiments at these two locations was a randomized complete block arrangement replicated four times. Plot size for all studies was 2.13 x 7.62 m. The soil at

Table 1. Monthly and yearly total precipatation for El Reno in 1982 and El Reno, Stillwater, and Woodward in 1983.

Month	El Reno 1982	El Reno 1983	Stillwater 1983	Woodward 1983
	----------	----------	cm	----------
January	7.87	4.32	0.84	1.42
February	2.92	1.73	7.65	4.57
March	5.46	6.10	7.77	8.81
April	4.83	8.76	4.14	3.61
May	29.36	18.16	18.87	7.42
June	11.30	13.34	9.27	12.37
July	10.74	0.00	0.00	0.00
August	0.00	15.62	2.24	1.52
September	5.46	4.07	5.21	9.58
October	0.64	22.65	19.33	6.35
November	5.11	4.06	5.49	3.71
December	3.50	4.45	1.02	0.00
TOTAL	87.19	103.26	81.83	59.36

El Reno was a Brewer (Fine, Mixed, Thermic Pachic Argiustoll) silty clay loam and Stillwater was a Easpur (Fine-loamy, Mixed, Thermic Fluentic Haplustoll) loam. Three rates (1.21, 2.24, 3.36 kg ai/ha) of atrazine and simazine were evaluated on Plains and Caucasian bluestem at the El Reno location in 1982. Propazine at three rates (1.12, 2.24, and 3.36 kg ai/ha) was an added treatment on these same two cultivars at El Reno in 1983. The three herbicides at the same three rates were also evaluated on Plains and Caucasian at Stillwater in 1983. The two cultivars used in all of these experiments were planted with a Nisbet[3] grassland drill at a planting rate of 2.8 kilograms pure-live-seed per hectare. Seeding and spraying information for each of the experiments is shown in Table 2. A clean, firm, well prepared seedbed was attained prior to planting. All field plots were fertilized prior to planting at soil test recommended rates.

Experimental data collected from the experiments included plant counts, visual weed control ratings, and forage yields. Plant counts for each of the experiments were taken 3 to 4 weeks after the planting date. Seedling plant counts of both Old World bluestem and weeds were taken randomly from each plot, with six (0.15 x 0.50 m) quadrats. The plant counts were totaled and converted to determine the number of live seedling per m^2 for both weed species and Old World bluestem cultivar.

Primary weed species varied by experiments. The major weed at El Reno in both years was redroot pigweed [Amaranthus retroflexus L. # AMARE]. In addition to redroot pigweed, the Plains bluestem study

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[3] A.R. Nisbet and Sons, Co., Inc., P.O. Box 1605, San Angelo, Texas 76901

Table 2. Cultivars studied, climatic conditions at seeding, and time of spraying and date of plant counts and forage yield data collected by study location.

Information	Experiment						
	El Reno-1982		El Reno-1983		Stillwater-1983		Woodward-1983
Cultivar in experiment	Caucasian	Plains	Caucasian	Plains	Caucasian	Plains	five[a]
Seeding date	6-17	6-17	6-08	6-08	5-26	5-26	5-26
Individual plot size	2.13 x 7.62m	2.13 x 7.62m	2.13 x 7.62m	2.13 x 7.62m	2.13 x 7.62m	2.13 x 7.62m	2.13 x 42.67m[b] 2.13 x 6.11m[c]
Spray information							
Date of application	6-17	6-17	6-08	6-08	5-26	5-26	5-27
Relative humidity	67%	67%	76%	76%	57%	57%	47%
Soil temp. (10cm)	27°C	27°C	24°C	24°C	27°C	27°C	24°C
Soil moisture	adequate	adequate	top dry subsoil adequate	top dry subsoil adequate	top dry subsoil adequate	top dry subsoil adequate	dry
Wind speed	3-5 mph	3-5 mph	5 mph	5.5 mph	1-3 mph	1-3 mph	10 mph
Date of plant counts	7-08	7-08	7-07	7-07	6-14	6-14	6-28
Date of production estimates	9-02	9-02	8-30	8-30	9-01	9-01	d

[a] The five cultivars used in the Woodward experiment include: Caucasian, WW-Spar, WW-517 (var. indica) WW-535 (var. ischaemum), WW-857 (var. Montana)

[b] Main plot

[c] Subplot

[d] Visual weed control ratings and forage yields were not obtained from the Woodward experiment due to poor growing conditions

at El Reno in 1983 had a heavy infestation of red sprangletop [Leptochloa filiformis (Lam.) Beauv. # LEFFI]. Weed species at the Stillwater experiments were primarily crabgrass, stinkgrass [Eragrostis cilianensis (All.) Lutati # ERAME] and tumble pigweed [Amaranthus albus L. # AMALL]. Forage yields for the various treatments were taken 3 to 4 months after planting. The species composition of the forage production was estimated prior to harvest based on percentage of stand. This was done by estimating percentages of each individual weed species and the Old World bluestem cultivar contributing to total dry matter production. Forage yields were determined by hand clipping forage from two (1.0 x 0.5 m) quadrats randomly selected from each plot. Forage clipped from each quadrat was oven dried for seven days at 70°C to determine dry matter production. Dry matter yields were corrected for the various forage components and listed as kg/ha of weeds and grass cultivar forage for each treatment. All experimental data was subjected to statistical analyses. Each experiment was analyzed separately. F-tests at the 5% level of significance were used to compare treatment effects. When F-tests were significant, LSD (0.05) values were used to compare treatment effects.

Woodward Experiment

The Woodward experiment initiated in 1983 consisted of five cultivars of Old World bluestem grasses as main plots (2.13 x 42.67 m) and seven herbicide treatments as subplots. Treatments consisted of no herbicide and 1.12 and 2.24 kg ai/ha rates of atrazine, simazine, and propazine. The study was conducted on a Pratt (Sandy, Mixed, Thermic Psammentic Haplustalf) fine sandy loam with four replications of each treatment. Plant counts were taken four weeks after planting. Information on dates and spraying conditions is shown in Table 2. Forage yields were not taken from this experiment due to poor growing conditions.

CHAPTER IV

RESULTS AND DISCUSSION

El Reno 1982 Experiments

Weed population in untreated plots of Plains at the time of seedling counts was two redroot pigweeds and three red sprangletop tops/m^2 (Table 3). Red sprangletop did not develop into a weed problem but redroot pigweed plants were very competitive and accounted for most of the weed production in untreated plots at harvest. Dry matter weed production in untreated plots of Plains was 2073 kg/ha. Control of these weeds was adequate with all three rates of atrazine and simazine. All treatments essentially eliminated weeds at time of early seedling counts, and production of weeds for the season was less than 150 kg/ha with all herbicide treatments.

Atrazine appeared to be selective enough to use as a preemergence herbicide on Plains at the El Reno location in 1982. There was no significant decrease of seedling establishment with atrazine. In addition, atrazine provided excellent control of weeds throughout the growing season. Also the highest forage yield of Plains (5448 kg/ha) was obtained from plots treated with 2.24 kg/ha of atrazine. Simazine was more phytotoxic to Plains than atrazine. The lowest numbers of plants and forage production was from plots treated with the highest rate (3.36 kg/ha) of simazine.

Table 3. Mean plant counts and forage dry matter produced by Plains and Caucasian bluestem as influenced by s-triazine herbicide rates at El Reno in 1982[a].

		Plains					Caucasian				
		Plant counts			Forage yield		Plant counts			Forage yield	
Herbicide	Rate	Plains	BLW[b]	WG[c]	Plains	Weeds[d]	Cauc.	BLW[b]	WG[c]	Cauc.	Weeds[d]
	(kg/ha)	---(Plants/m^2)-----			----(kg/ha)----		---(Plants/m^2)---			---(kg/ha)---	
Untreated	-----	195	2	3	4022	2073	498	6	6	3514	1668
Atrazine	1.12	207	0	0-	5086	134-	416	0-	0-	5392	72-
Atrazine	2.24	193	0	0-	5448+	0-	351-	0-	0-	5570+	0-
Atrazine	3.36	103	1	0-	3860	0-	314-	0-	0-	4538	0-
Simazine	1.12	106	0	0-	3723	0-	289-	0-	1-	4792	0-
Simazine	2.24	96	0	0-	2795-	0-	151-	0-	0-	3410	45-
Simazine	3.36	92	0	0-	1425-	23-	62-	0-	0-	2022	0-
LSD (0.05)		NS	NS	2	1100	1026	97	5	5	1955	383

[a] Values followed by (+) indicate significant increases from the untreated, those followed by (-) indicate significant decreases.
[b] Redroot pigweed
[c] Primarily red sprangletop
[d] Total weed yield consisted primarily of redroot pigweed

Weed population in untreated plots of Caucasian at the time of seedling counts was six redroot pigweeds and six red sprangletop plants/m^2 (Table 3). Dry matter weed production from untreated plots at harvest was (1668 kg/ha), consisting primarily of redroot pigweed. Weed competition was essentially eliminated with all herbicide treatments at time of early seedling counts. Good weed control persisted through the growing season resulting in less than 75 kg/ha of dry matter weed production.

Atrazine also appeared to be selective enough to use as a preemergence herbicide on Caucasian at the El Reno location in 1982. There was no significant decrease of seedling establishment of Caucasian at the 1.12 kg/ha rate and this rate of atrazine controlled all early weeds. The highest forage yield of Caucasian (5570 kg/ha) was obtained from plots treated with 2.24 kg/ha of atrazine. Simazine was also more phytotoxic to Caucasian than atrazine. Plots treated by the highest rate (3.36 kg/ha) of simazine had the lowest numbers of plants and dry matter forage production.

El Reno 1983 Experiments

There were six broadleaf weeds (primarily redroot pigweed) and 70 weedy grass plants/m^2 (primarily red sprangletop) in the untreated plots of Plains at the time of determining weed populations on July 7 (Table 4). Broadleaf weeds reduced in plots at the time of the July 7 plant counts by the 2.24 kg/ha rate of simazine and the 3.36 kg/ha rate of atrazine and propazine. The number of weedy grass seedlings were reduced by all herbicide treatments except for the 1.12 kg/ha propazine treatment. Weed production was not necessarily related to these early

Table 4. Mean plant counts and forage dry matter production by Plains and Caucasian bluestem as influenced by s-triazine herbicide rates at El Reno in 1983[a].

Herbicide	Rate	Plains: Plant counts: Plains	Plains: Plant counts: BLW[b]	Plains: Plant counts: WG[c]	Plains: Forage yield: Plains	Plains: Forage yield: BLW[b]	Plains: Forage yield: WG[c]	Caucasian: Plant counts: Cauc.	Caucasian: Plant counts: BLW[b]	Caucasian: Plant counts: WG[c]	Caucasian: Forage yield: Cauc.	Caucasian: Forage yield: BLW[b]	Caucasian: Forage yield: WG[c]
	(kg/ha)	----(Plants/m^2)----			------(kg/ha)------			----(Plants/m^2)---			-----(kg/ha)-----		
Untreated	-----	145	6	70	507	3260	2011	240	14	29	975	5477	309
Atrazine	1.12	149	3	36-	1048	2346	1901	251	3	46	5012+	722-	268
Atrazine	2.24	131	2	8-	4766+	0-	1031	260	10	22	4048+	165-	558
Atrazine	3.36	111-	0-	14-	2691	108-	899	222	1	31	4399+	193-	295
Simazine	1.12	111-	2	26-	853	981	3525	273	7	77	1352	4898	510
Simazine	2.24	69-	0-	18-	1462	1073	2442	156-	31	73	952	2296-	327
Simazine	3.36	53-	8	8-	1542	2418	655	173-	3	17	786	4281	770
Propazine	1.12	143	7	46	2198	1237	1563	271	4	32	2188	2325-	769
Propazine	2.24	166	3	27-	1988	0-	1922	258	6	32	2915+	2285-	830
Propazine	3.36	133	0-	31-	2578	150-	3332	259	1	61	3392+	737-	429
LSD (0.05)		33	5	28	2474	2631	NS	65	NS	NS	1726	2846	NS

[a] Values followed by (+) indicate signficant increases, those followed by (-), indicate significant decreases from the untreated

[b] Broadleaf weeds were primarily redroot pigweed

[c] Weedy grasses were red sprangletop

weed counts. There was a 15.62 cm of rain in August (Table 1), and as a result, there were many weeds produced in plots having good weed control in July. Forage yields of broadleaf weeds and weedy grasses were 3260 and 2011 kg/ha respectively in the untreated plots of Plains. Broadleaf weed production was not significantly reduced by any of the simazine treatments or the 1.12 kg/ha rate of atrazine or propazine. None of the treatments signficantly reduced dry matter production of the weedy grasses. The best and only significant forage production increase of Plains was with the 2.24 kg/ha rate of atrazine.

There were 14 broadleaf weeds and 29 weedy grass plants/m^2 in the untreated Caucasina experiment at the July 7 plant counts (Table 4). Forage production of these weeds was 5477 and 309 kg/ha respectively. The number of weed seedlings in the various plots was very variable, therefore, weed population differences among treatments were not significant. Herbicide treatments also had no effect on the dry matter production of the weedy grasses but some treatments did significantly reduce the yield of broadleaf weeds.

Propazine appeared to be as selective on Caucasian as atrazine. No reduction in number of seedling plants of Caucasian resulted with either atrazine or propazine treatments. However, propazine did not control the weeds as effectively as atrazine. The best bluestem forage yields consistently occurred with atrazine treatments. Simazine did not appear to have promise as a selective preemergence herbicide on Caucasian in this experiment. Stands were often reduced, plants stunted, and weed control was not satisfactory.

Stillwater 1983 Experiments

All herbicide treatments in the Plains experiment provided good early weed control and reduced forage production of weeds except for the 1.1 kg/ha rate of atrazine (Table 5). Simazine and propazine treatments also provided good weed control.

Evidence of herbicide injury to seedling stands was more apparent on the Stillwater loam experimental site. The increased herbicide availability with this soil caused stand reductions with all simazine and atrazine treatments. The two higher rates of propazine also reduced seedling stands of Plains early, but forage yields of Plains was signficantly increased by all rates of propazine.

In the Caucasian experiment, atrazine and simazine at all rates provided good weed control. Weed counts early were significantly reduced and production of weed dry matter was minimum with both herbicides. Propazine did give adequate control of broadleaf weeds, however weedy grass production was not reduced in the Caucuasin experiment by the two lower propazine rates.

The increased herbicide injury on Caucasian seedling was also apparent at the Stillwater loam site. Simazine at all rates and atrazine at the 2.24 and 3.36 kg/ha rates caused stunting of plants and stand reductions. There was no stand reduction of Caucasian with any rate of propazine.

Forage production of Caucasian was only increased by the 1.12 kg/ha rate of atrazine. Atrazine would again appear to be selective enough on Caucasian since weed control was adequate at the 1.12 kg/ha rate and maximum forage yield resulted with this treatment. Forage production

Table 5. Mean plant counts and forage dry matter production by Plains and Caucasian bluestem as influenced by s-triazine herbicide rates at Stillwater in 1983[a].

		Plains						Caucasian					
		Plant counts			Forage yield			Plant counts			Forage yield		
Herbicide	Rate	Plains	BLW[b]	WG[c]	Plains	BLW[b]	WG[c]	Cauc.	BLW[b]	WG[c]	Cauc.	BLW[b]	WG[c]
	(kg/ha)	----($Plants/m^2$)----			------(kg/ha)------			----($Plants/m^2$)----			-----(kg/ha)-----		
Untreated	-----	177	108	24	1042	133	1760	88	107	181	1368	586	1854
Atrazine	1.12	114-	35-	36	1282	0-	1288	82	12-	12-	3356+	0-	174-
Atrazine	2.24	55-	2-	0	634	0-	6-	40-	6-	6-	927	0-	131-
Atrazine	3.36	6-	16-	0	300	0-	0-	7-	1-	1-	338	0-	3-
Simazine	1.12	17-	15-	2	713	85	25-	11-	7-	7-	452	0-	233-
Simazine	2.24	5-	4-	0	71-	0-	4-	4-	2-	2-	0-	0-	0-
Simazine	3.36	0-	2-	0	65-	0-	0-	2-	4-	4-	0-	0-	0-
Propazine	1.12	151	8-	6	2188+	0-	357-	81	11-	29-	1325	77-	1641
Propazine	2.24	96-	14-	0	2834+	0-	239-	71	17-	22-	1409	0-	1179
Propazine	3.36	116-	11-	0	2167+	0-	67-	102	2-	7-	1334	0-	1050-
LSD (0.05)		49	52	NS	903	87	592	34	51	44	1291	202	795

[a] Values followed by (+) indicate significant increases, those followed by (-), indicate significant decreases

[b] Broadleaf weeds were primarily tumble pigweed

[c] Weedy grasses were primarily crabgrass and some stinkgrass

of Caucasian was drastically reduced by simazine with no production at the two higher rates. The lack of increased forage production of Caucasian with propazine was probably due to poor control of the weedy grasses.

Woodward 1983 Experiment

Weed infestation at this location consisted of pigweed and crabgrass (Table 6). Cultivars had no effect on weed population so results were pooled over herbicide treatments. All herbicide treatments provided excellent weed control of both pigweed and crabgrass. Stand establishment differed significantly among the five cultivars. Stand establishment in the untreated plots ranged from 208 plants/m^2 with WW-Spar to 38 plants/m^2 with Caucasian. Seedling establishment of cultivars was signficantly influenced by herbicide treatments. Both WW-Spar and WW-857 cultivars were significantly reduced by all herbicide treatments. The experimental WW-517 and WW-535 cultivars as well as Caucasian bluestem showed no significant stand reductions with any herbicide treatment. Propazine would appear to be the most selective of the three herbicides tested on this fine sandy loam soil. Plant counts from the propazine plots were consistently as good or better than from comparable rates of atrazine or simazine.

Table 6. Mean plant counts for five Old World cultivars as influenced by s-triazine herbicides at Woodward in 1983[a].

Herbicide	Rate	Weed Counts		Cultivar				
		PW[b]	CG[c]	WW-Spar	WW-857	WW-517	WW-535	Caucasian
	(kg/ha)	----------	----------	----------	(Plants/m^2)[c]	----------	----------	----------
Untreated	-----	79	46	208	150	71	76	38
Atrazine	1.12	1-	0-	83-	17-	102	66	31
Atrazine	2.24	0-	0-	67-	2-	81	52	11
Simazine	1.12	1-	0-	49-	5-	65	39	9
Simazine	2.24	0-	0-	27-	1-	47	45	3
Propazine	1.12	0-	5-	152-	79-	133	73	33
Propazine	2.24	0-	1-	97-	34-	111	52	20
LSD (0.05)		12	12	43	43	NS	NS	NS

[a] Values followed by (-) indicate a significant reduction in the number of seedlings from the untreated

[b] Pigweed

[c] Cragrass

CHAPTER V

SUMMARY AND CONCLUSIONS

Of the s-triazine herbicides evaluated, atrazine appeared to have the most potential as a selective herbicide on Old World bluestems. Weeds in Plains and Caucasian were selectively controlled by atrazine at the 1.12 or 2.24 kg/ha rate depending on weed species and soil type. Excellent broadleaf control was obtained with the 1.12 kg/ha on the loam site. Higher rates were needed to sufficiently control broadleaf weeds on the silty clay loam site. Adequate control of weedy grasses required 2.24 kg/ha on the Plains loam site. There was some phytoxicity associated with the 3.36 kg/ha rate of atrazine. Reductions in seedling numbers often resulted, particularly on the loam site. Also forage productions at this 3.36 kg/ha rate were not as good as lower rates of atrazine. Forage production of Plains bluestem was increased as much as 900% when weeds were selectively controlled with atrazine.

Simazine was more phytotoxic to all Old World bluestem cultivars tested than atrazine or propazine. Herbicide injury with simazine was very severe on the sandier soils. In addition, weed control with simazine was at times very poor.

Propazine was the least phytotoxic to the Old World bluestems of the three herbicides evaluated. Seedling Old World bluestem counts from propazine treated plots were consistently as good or better than from comparable rates of atrazine or simazine. However, propazine did not consistently control weeds.

It appears that seedling establishment of Old World bluestem can be significantly affected by cultivars. Seedling establishment of the cultivars WW-517, WW-535, Plains, and Caucasian were generally not reduced by atrazine and simazine. However seedling establishment of cultivars WW-Spar, and WW-857 were significantly reduced by all herbicide treatments. This indicates greater tolerance of some cultivars to the triazine herbicides. By selecting those cultivars that are more tolerant to triazine herbicides, weeds could be selectively controlled with little chance of injury to seedling stands of Old World bluestem.

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