Pricklypear Control with Fire and Herbicides on the Texas Rolling Plains

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ABSTRACT

A fire/herbicide system and the efficacy of picloram compared to triclopyr in this system was evaluated for pricklypear control. The study was initiated in 1987 and repeated in 1988, with control evaluated for 4 and 3 years post-treatment, respectively. Pricklypear response varied depending on year of application. Fire alone in the 1987 experiment did not provide sufficient control after 4 years. Fire plus picloram at 0.25 lb ai ac^{-1} provided 89% reduction of pricklypear canopy cover after 4 years. In 1987 unburned plots receiving the 0.25 lb ai ac^{-1} rate of picloram also provided the best control after 4 years (73% reduction). Fire alone in the 1988 experiment provided substantial control of pricklypear after 3 years (72% reduction). Pricklypear control in 1988 was enhanced by the addition of picloram treatments on burned plots. The addition of triclopyr to burned plots provided little benefit over that of fire alone. In 1987 unburned plots initial canopy cover played an important role in the comparison of pricklypear response to herbicide treatments. Picloram at 0.25 lb ai ac^{-1} applied to 1987 unburned plots generally provided better control than other treatments, but only when initial canopy cover was above specific amounts.

KEYWORDS: picloram, triclopyr, canopy cover, torrential rain, *Opuntia*

Pricklypear (*Opuntia* spp.) occupies about 25.4 million ac of rangeland in Texas (Lundgren et al., 1981). Only 8% of the ranchers in the High and Rolling Plains of Texas consider pricklypear to be beneficial to livestock production (Lundgren et al., 1981). Consumption of pricklypear fruits and cladophylls by livestock, especially sheep and goats, causes severe health problems (Merrill et al., 1980). Cactus spines frequently become imbedded in the tongues of cattle, predisposing the tongue to bacterial infection (Migaki et al., 1969). The discomfort caused by cactus spines can suppress livestock performance. Cactus glochids imbed in the lips, gums, tongues, stomachs, and intestines of sheep and goats causing ulceration and a subsequent decline in body condition, reduced lactation, and loss of young (Merrill et al., 1980).

Pricklypear can reduce forage availability for grazing (Petersen et al., 1988;

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Bement, 1968), compete with desirable forage plants, and interfere with movement and handling of livestock (Ueckert, 1982). Pricklypear can be controlled with herbicides (Wicks et al., 1969; Schuster, 1971; Kitchen et al., 1980; Price et al., 1985). Herbicidal control of brownspine pricklypear (*Opuntia phaecantha* Engelm. & Bigel) in the northern Rolling Plains did not affect total herbaceous forage production, but livestock carrying capacity increased in direct proportion to reduction in pricklypear canopy cover (Price et al., 1985). However, according to Ueckert (1982), aerial application of herbicides is not an economically feasible practice for many ranches. In contrast, the sequential application of prescribed fire and herbicides may significantly increase pricklypear control and thus be economically viable. Ueckert (1980) integrated prescribed fire with picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) spray applied at 0.5 lb ai ac^{-1}. He reported 99.6% reduction in canopy cover and 96% mortality of pricklypear the second season after treatment. Presently, a prescribed burn, followed by an application of picloram, is the fastest and most reliable way to control pricklypear. The fire destroys mulch and litter so that nearly all the picloram reaches bare soil (Ueckert, 1986), which may increase the actual amount of herbicide absorbed by the plant. The objectives of this study were to evaluate the use of a prescribed fire/herbicide system and to compare the efficacy of picloram to that of triclopyr {[(3,5,6-trichloro-2-pyridnyl)oxy]acetic acid} for pricklypear control in the northern Rolling Plains of Texas. Pricklypear (*Opuntia* spp.) classification follows Grant and Grant (1979). Other plant classification follows Correl and Johnston (1979).

MATERIALS AND METHODS

The study was conducted in the northern Rolling Plains on the West Fuller Ranch, 17 mi northwest of Snyder, Texas, in Scurry County. Soil is a Stamford clay (fine, montmorillonitic, thermic family of typic Chromusterts) with 0-5% slopes (Dixon et al., 1973). Average annual precipitation for Scurry County is 19.6 inches.

The dominant plant community is a honey mesquite (*Prosopis glandulosa* Torr.)-tobosagrass {*Hilaria mutica* (Buchl.) Benth.} type. Texas wintergrass (*Stipa leucotricha* Trin. and Rupr.), sideoats grama {*Bouteloua curtipendula* (Michx.) Torr.}, Texas grama {*B. rigidiseta* (Steud.) Hitchc.}, and buffalograss {*Buchloe dactyloides* (Nutt.) Engelm.} are subdominant to tobosagrass. *Opuntia edwardsii* was common throughout the site, and had hybridized forming intermediates with *O. phaeacantha major* and *O. lindheimeri*. Agarita (*Berberis trifoliolata* Moric.), Mormon tea (*Ephedra antisyphilitica* C.A. Mey.), and cholla (*Opuntia imbricata* Haw.) also occurred on the site.

The study was initiated March 1987 and repeated in 1988. Prior to burning 12, 0.56-ac plots were arranged in a completely randomized design within a 7-ac grazing exclosure. Three areas were burned each year and three were left unburned. Fire breaks were constructed around each main plot to be burned. Each of three plots was individually ringfired.

Herbicide treatments were randomly assigned to seven 16 by 98 ft subplots within each main plot. Each herbicide treatment was separated by a 16 by 98 ft border. Herbicide treatments included picloram applied at 0.12 and 0.25 lb ai ac^{-1}, and triclopyr applied at 0.12, 0.25, 0.50, and 1.0 lb ai ac^{-1}. One subplot in each main unit was left as an untreated check.

Live canopy cover of pricklypear was measured along four permanently marked 50-ft transects within each subplot. Canopy cover was recorded prior to treatment, and once per year thereafter. A completely randomized design with three replications was used. Analysis of variance was used to compare initial and post-treatment canopy cover within a treatment. Analysis of covariance was used to remove the influence of initial canopy cover and to compare post-treatment canopy cover between treatments.

Fine-fuel load was determined by clipping ten 0.25-m^2 rectangular quadrats in each main plot prior to burning. Samples were oven dried at 140 °F and weighed. Ten soil cores were taken from each main plot and soil water contents were determined gravimetrically (Black, 1965) (Table 1). Soil samples were collected from the 0 to 6 inch depth the day of the burn. Air temperature, humidity, and wind speed were monitored throughout ignition using a belt weather kit (Table 1). Rainfall data were averaged from the Texas Tech Experimental Ranch near Justiceburg, Texas (12 mi west of the study site) and NOAA 1987-88 Snyder, Texas station (15 mi southeast of study site).

Table 1. Environmental variables recorded at study site during application of fire treatments.

Date of Application	Ambient temperature	Relative humidity	Wind Speed	Soil water† content	Fine fuel‡ load
	(°F)	(%)	(mi hr^{-1})	(%)	(lb ac^{-1})
March 1987	64	38	6-14	22.7 ±2.2	2414 ±185
March 1988	63	33	5-9	16.7 ±1.5	1804 ±203

†Soil water content is the average of 30 samples taken at the 0 to 6 inch depth. Standard error is given below the mean.
‡Fine fuel load is the average of 30 samples taken from 3 plots prior to burning. Standard error is given below the mean.

Fire treatments were applied 7 March 1987 and 5 March 1988. Herbicide treatments were applied as foliar sprays 11-15 May 1987 and 23-27 May 1988 using a Solo backpack pump sprayer. Picloram was applied in 43 gal ac^{-1} water with 0.1% (v:v) commercial emulsifier. Triclopyr was applied in 43 gal ac^{-1} of a 1:14 (v:v) diesel fuel/water emulsion with 0.1% (v:v) commercial emulsifier. The amount of diesel used in the triclopyr formulations was higher than normally recommended which may make the triclopyr treatments less comparable to other studies. Herbicide applications were restricted to certain weather conditions. Temperature was between 61 and 81° F, relative humidity was greater than 25% and wind was less than 8 mi hr^{-1}.

RESULTS AND DISCUSSION

Pricklypear had started to resprout in burned plots and new cladophylls with true leaves were present in unburned plots at the time of herbicide application for both years. However, resprouting was less evident in 1988 burned plots and budbreak in 1988 unburned plots was less substantial than experienced in 1987.

Total rainfall was near the long term average in 1987 and 20% above normal in 1988. The study site received 7.4 inches within 2 weeks after herbicide application in 1987, and 2.3 inches within 1 week after herbicide application in 1988. Fine fuel averaged 2414 (S.E.=185) lb ac^{-1} in 1987 and 1804 (S.E.=203) lb ac^{-1} in 1988 (Table 1).

Pricklypear canopy cover in the 1987 experiment was reduced ($P \leq 0.05$) 1, 2, 3, and 4 years after fire plus picloram treatment at 0.25 lb ai ac^{-1} (Table 2). Percent reduction from initial canopy cover increased each year to a high of 89%, 4 years post-treatment. Higher rates of picloram may have provided better and faster control, as shown by Ueckert (1980) where canopy cover was reduced 99.6% the second season after fire plus picloram treatment at 0.50 lb ai ac^{-1}.

Fire alone in the 1987 experiment did not reduce ($P \geq 0.05$) pricklypear canopy cover at any post-treatment period (Table 2). These results are not consistent with those of Ueckert et al. (1982) where canopy cover was reduced 85% 6 months after fire. Bunting et al. (1980) reported only a 20% mortality of brownspine pricklypear 6 months after fire, but mortality was reported to exceed 70% by the end of the third year. Mortality, however, may not be comparable to canopy cover data.

The fire plus 0.25 lb ai ac^{-1} rate of picloram reduced pricklypear canopy cover more consistently than any other treatment in the 1987 experiment. Reduction was greater ($P \leq 0.05$) 3 and 4 years post-treatment than any other treatment, except for fire plus 1.0 lb ai ac^{-1} rate of triclopyr the fourth year post-treatment (Table 2).

Pricklypear canopy cover in 1987 unburned plots was increased ($P \leq 0.05$) from initial canopy cover by the 0.12 lb ai ac^{-1} rate of triclopyr 2, 3, and 4 years post-treatment (Table 3). Post-treatment canopy cover of areas treated with picloram at 0.25 lb ai ac^{-1} did not differ ($P \geq 0.05$) from initial canopy cover at any post-treatment period, although reduction reached 73% after 4 years. Changes in post-treatment canopy cover were apparent even after 4 years and would indicate that long-term monitoring is necessary to fully evaluate treatment effects.

In 1987 unburned plots, different slopes for the response of post-treatment canopy cover to initial canopy cover for some treatments was detected ($P \leq 0.01$). This indicated that some post-treatment responses were influenced by initial canopy cover. Therefore, to test for differences between treatments, the region of significance in initial canopy cover was calculated for all pairwise comparisons of treatments with a separate slopes model (Searle, 1987) (Table 4). For example, the 0.25 lb ai ac^{-1} rate of picloram reduced ($P \leq 0.05$) pricklypear canopy cover more than the untreated check 3 and 4 years post-treatment, but only if initial canopy was greater than 1.5 and 1.3%, respectively. These data suggest that if initial canopy cover is low, then a picloram treatment at rates used in this study may not be appropriate for pricklypear control. If initial canopy cover is low, then a fire treatment may be warranted since fine fuel load may be negatively correlated to pricklypear canopy cover. There also may be an upper range of initial canopy cover when fire alone will not achieve substantial control, and the picloram treatment should be used along with fire. Additionally, areas with very high initial canopy cover may not support

Table 2. Percent initial and post-treatment canopy cover of pricklypear from 1987 burned plots.

Treatment (lb ac^{-1})	Initial	Canopy Cover (%) Years After Treatment 1	2	3	4
Fire plus	2.73	2.54[†]	1.92	1.72	1.60
Picloram		2.95[‡] a	2.16 a	2.00 a	1.82 a
(0.12)		-7[§]	-30	-37	-41
Fire plus	3.45	1.47 *	1.08 *	0.58 *	0.38 *
Picloram		1.32 b	0.99 b	0.47 b	0.30 b
(0.25)		-57	-69	-83	-89
Fire plus	3.83	3.44	2.44 *	3.28	2.49 *
Triclopyr		3.00 a	2.17 a	2.97 ac	2.25 a
(0.12)		-10	-36	-14	-35
Fire plus	3.50	2.74	2.63	3.17	2.91
Triclopyr		2.56 a	2.51 a	3.04 ac	2.81 a
(0.25)		-22	-25	-9	-17
Fire plus	3.10	2.05 *	2.16	2.78	2.55
Triclopyr		2.17 ab	2.23 a	2.87 a	2.62 a
(0.50)		-34	-30	-10	-18
Fire plus	2.83	2.37	1.53	1.95	1.44 *
Triclopyr		2.69 a	1.73 ab	2.18 ac	1.62 ab
(1.0)		-16	-46	-31	-49
Fire only	3.36	2.95	2.67	3.29	2.94
		2.87 a	2.62 a	5.24 c	2.90 a
		-12	-21	-2	-13

†Actual means within a row of post-treatment canopy cover followed by an asterisk are different ($P<0.05$), AOV, from the initial canopy cover.

‡The second number within a row and column are adjusted means based on initial canopy cover as a covariable, ANCOVA. Adjusted means within a column followed by different letters are different ($P<0.05$).

§Percent change is based on initial and the actual post-treatment canopy cover.

Table 3. Percent initial and post-treatment canopy cover of pricklypear from 1987 unburned plots.

Treatment (lb ac^{-1})	Initial	Canopy Cover (%) Years After Treatment 1	2	3	4
Picloram	1.43	1.88†	1.54	1.77	1.56
(0.12)		2.33‡ ab	¶abc	ab	ab
		+31§	+8	+24	+9
Picloram	1.64	1.32	0.82	0.52	0.44
(0.25)		1.51 a	a	a	a
		-20	-50	-68	-73
Triclopyr	1.26	1.98	2.83 *	3.48 *	3.07 *
(0.12)		2.63 b	b	b	b
		+57	+125	+176	+144
Triclopyr	1.06	1.30	1.43	1.66	1.48
(0.25)		2.20 ab	abc	ab	b
		+23	+35	+57	+40
Triclopyr	2.23	2.96	2.73	3.29	2.64
(0.50)		2.44 b	c	b	b
		+33	+22	+48	+18
Triclopyr	3.21	3.24	5.06 *	5.05 *	4.08
(1.0)		1.54 a	bc	b	b
		+3	+58	+57	+27
Untreated	1.58	1.83	1.92	2.58	1.91
		1.86 ab	c	b	b
		+16	+22	+63	+21

†Actual means within a row of post-treatment canopy cover followed by an asterisk are different ($P<0.05$), AOV, from the initial canopy cover.
‡The second number within a row and column are adjusted means based on initial canopy cover as a covariable, ANCOVA. Adjusted means within a column followed by different letters are different ($P<0.05$).
§Percent change is based on initial and the actual post-treatment canopy cover.
¶Means 2,3, and 4 years post-treatment within a column followed by different letters are different ($P<0.05$), ANCOVA and seperate slopes model, but only at the specified region of significance of initial canopy cover given in Table 4.

Table 4. Regions of significance for 2,3,4 years post-treatment in 1987 unburned plots.

2 year Post-treatment	
Significant treatment Comparisons (lb ai ac^{-1})	Initial % Canopy Cover Regions of Significance
Picloram 0.25 and Triclopyr 0.12	>1.12
Picloram 0.25 and Triclopyr 0.50	>1.56
Picloram 0.25 and Triclopyr 1.0	>2.48
Picloram 0.25 and Untreated	<0.45 or >1.28
Triclopyr 0.12 and Triclopyr 0.50	1.25 to 1.76
Triclopyr 0.12 and Untreated	1.18 to 1.86

3 year Post-treatment	
Significant treatment Comparisons (lb ai ac^{-1})	Initial % Canopy Cover Regions of Significance
Picloram 0.25 and Triclopyr 0.12	1.05 to 2.45
Picloram 0.25 and Triclopyr 0.50	>1.95
Picloram 0.25 and Triclopyr 1.0	>2.07
Picloram 0.25 and Untreated	>1.47

4 year Post-treatment	
Significant treatment Comparisons (lb ai ac^{-1})	Initial % Canopy Cover Regions of Significance
Picloram 0.25 and Triclopyr 0.12	1.12 to 1.79
Picloram 0.25 and Triclopyr 0.25	1.05 to 1.49
Picloram 0.25 and Triclopyr 0.50	>0.91
Picloram 0.25 and Triclopyr 1.0	>1.50
Picloram 0.25 and Untreated	1.29

enough fine fuel for an adequate fire, and higher rates of picloram alone may be needed for sufficient control of pricklypear.

Pricklypear canopy cover in the 1988 experiment was reduced ($P \leq 0.05$) in burned plots after 1, 2, and 3 years for all treatments (Table 5). Canopy cover was reduced 98% by fire plus the 0.12 and 0.25 lb ai ac^{-1} rates of picloram, and 72% by fire alone after 3 years. The 1988 results are more consistent with those found in earlier research (Ueckert et al., 1982; Bunting et al., 1980).

Table 5. Percent initial and post-treatment canopy cover of pricklypear from 1988 burned plots.

Treatment ($lb\ ac^{-1}$)	Canopy Cover (%) Initial	Years After Treatment 1	2	3
Fire plus Picloram (0.12)	4.38	0.80† *	0.17 *	0.09 *
		0.99‡	0.61	0.31 a
		-82§	-96	-98
Fire plus Picloram (0.25)	4.12	0.94 *	0.21 *	0.08 *
		1.19	0.52	0.36 ab
		-77	-95	-98
Fire plus Triclopyr (0.25)	6.22	0.99 *	1.50 *	1.01
		0.78	1.13	0.76 ab
		-84	-76	-84
Fire plus Triclopyr (0.50)	4.31	0.62 *	1.42 *	0.86 *
		0.83	1.64	1.10 ab
		-86	-67	-80
Fire plus Triclopyr (0.50)	4.19	0.23 *	0.63 *	0.61 *
		0.46	0.70	0.87 ab
		-86	-85	-85
Fire plus Triclopyr (1.0)	6.88	1.12 *	2.11 *	1.59 *
		0.76	1.81	1.17 ab
		-84	-69	-77
Fire only	6.59	1.84 *	2.67 *	1.85 *
		1.55	2.30	1.51 b
		-72	-59	-72

†Actual means within a row of post-treatment canopy cover followed by an asterisk are different ($P<0.05$), AOV, from the initial canopy cover.

‡The second number within a row and column are adjusted means based on initial canopy cover as a covariable, ANCOVA. Adjusted means within a column followed by different letters are different ($P<0.05$).

§Percent change is based on initial and the actual post-treatment canopy cover.

Adjusted canopy cover means between treatments differed (P≤0.05) only between fire plus the 0.12 lb ai ac^{-1} rate of picloram and fire alone after 3 years (Table 5). Most of the reduction apparently was due to the fire treatment. Long-term monitoring, however, is needed to determine the longevity of these treatments.

In the 1988 unburned plots, post-treatment canopy cover differed (P≤0.05) from initial canopy cover after 3 years in areas treated with the 0.25 lb ai ac^{-1} rate of picloram (Table 6). The 0.12 and 0.25 lb ai ac^{-1} rate of picloram provided better control (P≤0.05), 37 and 64% reduction of canopy cover respectively, than other treatments. Additionally, the effects of picloram treatments on canopy cover probably are not fully manifested after 3 years as other biological factors may continue to influence the weakened plants.

Table 6. Percent initial and post-treatment canopy cover of pricklypear from 1988 unburned plots.

Treatment	Canopy Cover (%)			
		Years After Treatment		
(lb ac^{-1})	Initial	1	2	3
Picloram (0.12)	4.57	4.16†	3.34	2.86
		2.55‡ a	1.51 a	0.31 ac
		-9§	-27	-37
Picloram (0.25)	3.23	4.05	2.21	1.16 *
		3.88 b	2.54 ab	1.04 a
		+25	-32	-64
Triclopyr (0.12)	3.05	3.39	3.85	3.63
		3.41 ab	3.68 abc	3.65 b
		+11	+26	+19
Triclopyr (0.25)	2.26	2.60	3.54	3.22
		3.48 ab	5.27 abc	2.83 b
		+15	+57	+42
Triclopyr (0.50)	1.79	2.01	2.74	2.53
		3.39 ab	4.04 abc	3.47 b
		+12	+53	+41
Triclopyr (1.0)	3.61	4.01	4.19	3.31
		3.42 ab	3.22 abc	2.91 bc
		+11	+16	-8
Untreated	2.99	2.73	3.66	3.06
		2.82 ab	4.31 bc	3.12 b
		-9	+22	+2

†Actual means within a row of post-treatment canopy cover followed by an asterisk are different (P<0.05), AOV, from the initial canopy cover.
‡The second number within a row and column are adjusted means based on initial canopy cover as a covariable, ANCOVA. Adjusted means within a column followed by different letters are different (P<0.05).

CONCLUSIONS

Rainfall appeared to play an important role in the efficacy of treatments for control of pricklypear. Rainfall after herbicide application is critical, especially for picloram which is both foliar and root absorbed. Torrential rains, however, many inhibit lethal concentrations of herbicide from entering plant systems. In the 1987 experiment fire alone did not provide sufficient control of pricklypear after 4 years. Fire plus picloram at 0.25 lb ai ac^{-1} gave the best control after 4 years (89% reduction in canopy cover). In unburned plots, the 0.25 lb ai ac^{-1} rate of picloram also provided the best results after 4 years (73% reduction in canopy cover). This would indicate that certain years would require more than fire alone or treatments other than fire to obtain sufficient control of pricklypear. Higher rates of picloram also may provide quicker and better control.

Fire alone in the 1988 experiment provided substantial control of pricklypear after 3 years (72% reduction in canopy cover). The addition of picloram treatments to burned plots enhanced control over that of fire alone, however, the cost of the additional picloram should be evaluated if it is known that fire alone will give substantial control. Pricklypear response to fire alone appears variable and at this time the addition of the picloram treatment should give more consistent control.

Determining initial canopy cover before treatment application for pricklypear control may provide important insight to which type of treatment should be used. There may be a range of initial canopy cover that can be controlled by fire alone, fire plus picloram, or picloram alone. Further studies are needed to evaluate how initial canopy cover influences treatment efficacy.

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