Winter forb control for increased grass yield on sandy rangeland

BILL E. DAHL, JEFFREY C. MOSLEY, PAUL F. COTTER, AND ROY L. DICKERSON, JR.

Abstract

Four separate studies evaluated several herbicides for reducing competition from overwintering weeds on sandy rangeland in west Texas. Air temperature was 10° C with soil moisture adequate for plant growth at herbicide application (0.28 kg ae/ha) on 14 March 1985. Trichlopyr ([3,5,6-trichloro-2-pyridinyl)oxy]acetic acid); 2,4-D [(2,4-dichlorophenoxy)acetic acid]; and dicamba (3,6-dichloro-2-methoxybenzoic acid) plus 2,4-D were ineffective, while picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid); picloram plus 2,4-D; and dicamba alone adequately controlled western ragweed (*Ambrosia psilostachya* DC.), the major targeted weed. These treatments were repeated on 4 April 1986 when air temperature was 24° C but with dry surface soils. Results were similar to those of 1985, except trichlopyr also controlled western ragweed under the warmer temperature. In another study, various rates of picloram and trichlopyr aerially applied 5 April 1986 showed that 0.07 kg ae/ha of picloram or 0.28 kg ae/ha of trichlopyr reduced ($P<0.05$) western ragweed with a corresponding increase in grass production. Picloram more effectively controlled targeted forbs while trichlopyr suppressed sand shinnery oak (*Quercus havardii* Rydb.) more effectively. Two companion studies also evaluated picloram and picloram plus 2,4-D. In one study 0.28 kg ae/ha of picloram was applied to sand shinnery oak range on 11 March 1985. Grass yield increased from 359 kg/ha in untreated plots to 1,222 kg/ha in treated plots. Grass yield in treated areas remained greater ($P<0.05$) for 3 growing seasons post-treatment. Sand shinnery oak plants at the bud burst stage were top-killed by picloram. On 14 March 1985 picloram (0.056 kg ae/ha) plus 2,4-D (0.224 kg ae/ha) was applied to sand shinnery oak rangeland. This treatment reduced forb production with a corresponding increase in grass production the year of application ($P<0.05$), but effects did not persist into the second growing season. Picloram plus 2,4-D did not suppress sand shinnery oak.

Key Words: herbicides, sand shinnery oak, *Quercus havardii* Rydb.

Winter forbs on sandy rangeland occur at sufficient densities some years to suppress grass growth the following summer. Dense populations of undesirable winter forbs result from favorable environment for germination and stand establishment rather than removal of competing vegetation by excessive grazing (Sosebee 1983, Hylton and Bement 1961). However, declines in grass cover or vigor do encourage dense stands of weedy forbs when combined with favorable weather conditions. Summer drought in 1983 in west Texas followed by high October rainfall resulted in sufficient growth by perennial grasses to deplete their root and crown energy reserves before a killing frost. Three weeks of record cold in December weakened or killed these plants and only 1 or 2 tillers per plant grew from surviving grasses the following spring. Although 1984 was a drought year (NOAA 1984) and neither grasses nor forbs thrived, favorable 1984–85 fall and winter precipitation and temperatures resulted in large populations of winter and annual and biennial forbs.

Because winter forbs can drastically suppress growth of vigorous warm-season perennial grasses in west Texas (Sosebee 1979, Ueckert 1979), we anticipated that weakened grasses faced potentially severe competition during spring and summer 1985 from the dense stands of establishing winter forbs. The objectives of this study were: (1) to evaluate several herbicides for reducing competiton from overwintering undesirable forbs; (2) to compare grass response following herbicidal treatments; and (3) to determine whether herbicidal control benefited perennial grasses through the second year after treatment.

Study Area and Methods

The study was conducted from 1985–1987 on the Post-Montgomery Estate and Middleton Ranches located 15 and 20 km northeast of Post, Texas, respectively. Average annual precipitation is 480 mm, approximately 75% occurring from May through October (Richardson et al. 1965). Soils on study sites are mostly Brownfield fine sand, a loamy, mixed thermic Arenic Aridic Paleustalf (Richardson et al. 1965). Vegetation was dominated by sand shinnery oak (*Quercus havardii* Rydb.) and fringed signalgrass (*Brachiaria ciliatissima* [Buckl.] Chase). Other common species included sand dropseed (*Sporobolus cryptandrus* [Torr.] A. Gray), little bluestem (*Schizachyrium scoparium* [Michx.] Nash), hooded windmill grass (*Chloris cucullata* Bisch.), purple threeawn (*Aristida purpurea* (Nutt.), fall witchgrass (*Leptoloma cognatum* [Schult.] Chase), sand paspalum (*Paspalum setaceum* (Michx.), western ragweed (*Ambrosia psilostachya* DC.), and erect dayflower (*Commelina erecta* L.).

The study consisted of 4 separate experiments: (1) use of picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) to control winter-growing weedy forbs; (2) use of picloram plus 2,4-D [(2,4-dichlorophenoxy)acetic acid] to control winter-growing weedy forbs; (3) a herbicide comparison repeated over 2 years to evaluate cost-effective methods for controlling winter-growing weedy forbs; and (4) a herbicide rate comparison using trichlopyr ([3,5,6-trichloro-2-pyridinyl)oxy]acetic acid] and picloram to suppress sand shinnery oak and winter-growing weedy forbs.

Study 1

Sixty-five ha of sand shinnery oak rangeland were evaluated for forb response with and without picloram herbicide during 1985–1987. Picloram at 0.28 kg ae/ha was applied to 32.5 ha on 11 March 1985. The remaining 32.5 ha were in four 8.1-ha untreated plots on each side of the treated plot. Herbicide was applied from a sprayer mounted in a pickup truck using a boomless nozzle with a cluster of 5 spray jets. Swath width was 13 m. Air temperature reached a maximum of 26° C during application. Soil moisture was not sampled but precipitation from October to March exceeded 254 mm, which provided adequate soil moisture for plant

Authors are professor, Range and Wildlife Management Department, Texas Tech University, Lubbock 79409; assistant professor, Range Resources Department, University of Idaho, Moscow 83843; research assistant, Range and Wildlife Management Department, Texas Tech University, Lubbock 79409; and technical manager, Beef Cattle Group, Purina Mills, Inc., Box 66812, St. Louis, Missouri 63166. At the time of the research Mosely and Dickerson were research assistants Range and Wildlife Management Department, Texas Tech University, Lubbock 79409.

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growth. Forbs were in the early vegetative stage when herbicide was applied. A few sand shinnery oak plants were breaking bud, with most plants apparently fully dormant. Grass and forb yield was determined in July 1985, 1986, and 1987 by clipping 35 randomly located 0.4-m^2 quadrats in both treated and untreated plots. The treated plot was grazed by cattle during the study, so quadrats were located inside cages. The adjacent untreated plots were ungrazed during the growing season so cages were not used in the untreated plots. Site constraints prohibited true random location of treatments. Therefore, the error term in the analysis of variance was the nested variation of the randomized quadrats within the study area (Dunn and Clark 1974).

Study 2

On 14 March 1985 picloram plus 2,4-D (4 parts 2,4-D and 1 part picloram) at 0.28 kg ae/ha was applied to two 0.4-ha plots. Two untreated 0.4-ha plots interspersed between the treated plots served as the control. In addition, a 0.2-ha buffer was left untreated between all treatment plots so that spray drift would not influence subsequent vegetation sampling. Air temperature remained about 10° C during herbicide application. Above-average winter rainfall had provided adequate moisture in the top 60 cm of soil for plant growth. All sand shinnery oak plants appeared dormant when herbicide was applied but forbs were in early vegetative stage. Grass and forb standing crop was clipped within ten 0.4-m^2 quadrats in each of the four 0.4-ha plots in July 1985 and 1986.

Study 3

On 14 March 1985 we applied 2,4-D; a mixture of 3 parts 2,4-D and 1 part dicamba (3,6-dichloro-2-methoxybenzoic acid); trichlopyr; dicamba; picloram; and picloram plus 2,4-D (4 parts 2,4-D and 1 part picloram) each at 0.28 kg ae/ha to sand shinnery oak rangeland. Also, 2,4-D was applied at 0.56 kg ae/ha. Experimental design was completely random with 3 replications. Each plot was 0.4 ha. Including 3 untreated plots, there were 24 plots within the study area on the Post-Montgomery Estate Ranch. Herbicides were ground applied as in Studies 1 and 2. A 9-m wide buffer strip was left untreated between all plots. Sand shinnery oak appeared totally dormant when herbicides were applied. Oak plants were sparse because the site had been treated with tebuthiuron (*N*[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N,N'*-dimethylurea) in 1981. Forbs were in early vegetative growth stages. Treatment plots were unfenced and grazed by cattle, so species frequency was used to evaluate plant response. Air temperature was about 10° C during herbicide application. Soil moisture in the top 60 cm was adequate for plant growth.

The study was repeated in 1986 on the adjacent Middleton Ranch, where treatment plots were fenced, using the same herbicides and rates as in 1985. In addition, dichlorprop [-2(2,4-dichlorophenoxy)propanoic acid] at 0.28 kg ae/ha was also applied. Herbicides were applied on 4 April 1986 with air temperature about 24° C. However, soil moisture was only the top 30 cm and only 4.1% in the second 30 cm; little forb growth was occurring due to insufficient moisture. Sand shinnery oak had been suppressed by tebuthiuron application in 1983. Remaining oak plants were all in early vegetative stage (miniature leaves). Western ragweed was the only herbaceous plant of sufficient density to warrant control. Its new shoots were about 2.5 cm tall. Treatment plots were 0.2 ha arranged in a completely random design.

Plant response was evaluated with forty 0.25-m^2 frequency quadrats per plot in July 1985 for the Post-Montgomery Estate plots. These plots were resampled in July 1986 with twenty 0.25-m^2 frequency quadrats per plot. The 1986 herbicide applications on the Middleton Ranch were sampled with twenty 0.25-m^2 frequency quadrats per plot in July 1986. Also, five 0.4-m^2 quadrats were clipped in each of the Middleton Ranch plots in July 1986 to evaluate impact of weed control on forage yield.

Study 4

McIlvain and Armstrong (1974) used ultra-low rates of 2,4,5-T to suppress sand shinnery oak and give grasses a competitive edge at low cost. This study was designed to evaluate alternatives to 2,4,5-T and to examine the oak suppression potential of picloram. On 5 April 1986 picloram at 0.07, 0.14, and 0.28 kg ae/ha; trichlopyr at 0.28 and 0.56 kg ae/ha; and a mixture of picloram and trichlopyr each at 0.28 kg ae/ha were applied aerially on 6-ha plots on the Middleton Ranch. The entire east half of the treated area had been treated with tebuthiuron in 1983 and the west half had no previous herbicide treatment. However, forb response did not differ ($P<0.05$) between east and west portions so values were pooled in analyses. Experimental design was a randomized block with 2 complete blocks. Untreated plots in each block were 12 ha instead of 6 ha to facilitate subsequent vegetation sampling away from any herbicide drift. Air temperature was 24° C when herbicides were applied and soil moisture was low as described in Study 3. All sand shinnery oak plants had produced at least miniature leaves and western ragweed was about 2.5 cm tall. Herbage yield was obtained in July 1986 by clipping ten 0.4-m^2 quadrats per herbicide plot. Western ragweed control was evaluated with twenty 0.25-m^2 frequency quadrats per plot in December 1986. We also determined sand shinnery oak mortality by dead-alive analysis in December from forty 0.25-m^2 quadrats per treatment plot. Oak plants in a quadrat were considered either all dead or all alive if any part of the plant was alive. Other weeds did not occur commonly enough for statistical evaluation.

Data Analysis

Statistical analyses for Studies 1 through 4 were one- and two-way analyses of variance. Frequency data were analyzed by chi square as well as by analyses of variance after arc sine transformation (Steel and Torrie 1980); untransformed data are presented. Percent mortality of sand shinnery oak was arc sine transformed (Sokal and Rohlf 1981) prior to analysis of variance. Chi square analyses and analyses of variances yielded similar results; tables presented use analysis of variance format. Mean separation was by Fisher's protected LSD test.

Results and Discussion

Study 1

Picloram at 0.28 kg ae/ha on 11 March 1985 suppressed broad-leaved forbs that had germinated. Surprisingly, sand shinnery oak plants that were at the bud burst stage were also top-killed. The

Table 1. Herbaceous standing crop in July 1985, 1986, and 1987 following ground application of picloram (0.28 kg ae/ha) to sand shinnery oak rangeland on the Post-Montgomery Estate Ranch near Post, Texas on 11 March 1985.

Sampling date	Vegetation component	Standing crop	
		Treated	Control
		(kg/ha)	
1985	Grass	1222a[1]	359b
	Forbs	62a	359b
1986	Grass	1104a	527b
	Forbs	56a	118a
1987	Grass	1642a	807b
	Forbs	336a	471b

[1]Numbers in the same row followed by the same letter are not significantly different ($P<0.05$).

Table 2. Herbaceous standing crop in July 1985 and 1986 following ground application of picloram plus 2,4-D (0.056 + 0.224 kg ae/ha) to sand shinnery oak rangeland on the Post-Montgomery Estate Ranch near Post, Texas on 14 March 1985.

Sampling date	Vegetation component	Standing crop Treated	Standing crop Control
		(kg/ha)	
1985	Grass	1939a[1]	572b
	Forbs	202a	790b
1986	Grass	1216a	1076a
	Forbs	56a	106a

[1]Numbers in the same row followed by the same letter are not significantly different ($P<0.05$).

desirable, summer-growing velvet bundleflower (*Desmanthus velutinus* Scheele) and erect dayflower appeared unharmed by the herbicide. These species had not emerged at the time of application. By early July, grass yield increased ($P<0.01$) from 359 kg/ha in untreated plots to 1,222 kg/ha in treated plots (Table 1). Forb yield was 62 kg/ha where treated with picloram compared to 359 kg/ha without the herbicide. The fact that total herbaceous yield was 1,284 kg/ha in treated plots and only 717 kg/ha in untreated plots (Table 1) is assumed due to sand shinnery oak suppression.

Winter and spring of 1985–86 produced few forbs, and there was no difference in 1986 forb yield between treatments. However, 1986 grass yield in treated plots was twice that in untreated plots (Table 1). We attribute this to reduced competition from early growing forbs and sand shinnery oak. By 1987, visual differences between picloram-treated (in 1985) and untreated plots had largely dissipated. Nevertheless, grass production in treated plots was still considerably greater and forb production less ($P<0.05$) than in untreated plots (Table 1).

Study 2

Unlike the picloram treatment in Study 1, picloram plus 2,4-D did not suppress sand shinnery oak. It did reduce ($P<0.05$) forb production the year of treatment by 588 kg/ha (Table 2), and increased grass standing crop by 1,367 kg/ha. However, there was no carry-over effect into 1986 as with the picloram-treated pastures (Table 2). This study was not designed to compare picloram vs. picloram plus 2,4-D. However, Studies 1 and 2 were adjacent to each other, so we suspect the lack of carry-over effect with the

Table 3. Frequency of western ragweed in 0.25-m² quadrats following herbicide treatments to sand shinnery oak rangeland on the Post-Montgomery Estate Ranch on 14 March 1985 and evaluated in July 1985 and 1986. The study was repeated on the Middleton Ranch on 4 April 1986 and evaluated in July 1986.

Treatment	Rate	Western ragweed frequency: Post-Montgomery Estate Ranch 1985	Post-Montgomery Estate Ranch 1986	Middleton Ranch 1986
	(kg ae/ha)	(%)		
Control	0.00	60a[1]	45ab	50a
2,4-D	0.28	58a	53ab	50a
2,4-D	0.56	65a	60a	42ab
Dicamba + 2,4-D	0.07 + 0.21	67a	33abc	37abc
Trichlopyr	0.28	80a	48ab	12c
Dicamba	0.28	27b	32abc	5c
Picloram + 2,4-D	0.056 + 0.224	23b	10bc	7c
Picloram	0.28	2c	0c	15c
Dichlorprop	0.28	—	—	30abc

[1]Numbers in the same column followed by the same letter are not significantly different ($P<0.05$).

Table 4. Herbaceous standing crop in July 1986 following ground herbicide application on 4 April 1986 to sand shinnery oak rangeland on the Middleton Ranch near Post, Texas.

Herbicide	Rate	Standing crop Grass	Standing crop Forbs
	(kg ae/ha)	(kg/ha)	
Control	0.00	802a[1]	353a
2,4-D	0.28	1267ab	196abc
2,4-D	0.56	1127ab	291ab
Dichlorprop	0.28	1496ab	129bc
Dicamba + 2,4-D	0.07 + 0.21	1435ab	185abc
Trichlopyr	0.28	1900b	73c
Dicamba	0.28	1317ab	45c
Picloram + 2,4-D	0.056 + 0.224	1872b	95bc
Picloram	0.28	1379ab	45c

[1]Numbers in the same column followed by the same letter are not significantly different ($P<0.05$).

picloram plus 2,4-D was due to its lack of effectiveness on sand shinnery oak.

Study 3

Targeted annual weeds were camphor weed (*Heterotheca latifolia* Buckl.) annual buckwheat (*Eriogonum annuum* Nutt.), yellow woollywhite (*Hymenopappus flavescens* Gray), and spectacle pod (*Dithyrea wislizenii* Engelm). Western ragweed was the most common perennial weed. Under the cool environment at the time of application in 1985, 2,4-D; 2,4-D plus dicamba; and trichlopyr were ineffective. Only picloram achieved greater than 90% control of targeted weeds ($P<0.05$). Picloram plus 2,4-D and dicamba alone also had less ragweed ($P<0.05$) than in the other treatments (Table 3). In 1986 no western ragweed was found on the Post-Montgomery Estate Ranch plots treated with picloram. Because of the dry conditions in the winter of 1985–86, few annuals germinated.

In 1986 on the Middleton Ranch plots, dry soil prevented germination of annuals so western ragweed was the only species targeted for herbicidal control. Since Ueckert et al. (1980) found poor response from 2,4-D when applied during cold air temperatures, we applied the 1986 treatments on 4 April 1986 when air temperature was 24° C. The surface 30 cm of soil had only 1.0% water and the second 30 cm had 4.1%, thus little water was available for seedling growth. There is evidence that dry soils prevent or reduce 2,4-D effectiveness as well as low air temperature (Hormay et al. 1962, Jones et al. 1982, Mayeux and Scifres 1981, Sperry and Sultemeir 1965). This was apparent for our 2,4-D applications as no visible difference existed between 2,4-D and control plots. Also,

Table 5. Vegetation response to various herbicide treatments applied aerially to 6-ha plots on 5 April 1986 to sand shinnery oak rangeland on the Middleton Ranch near Post, Texas. Standing crop was evaluated in July 1986 and western ragweed frequency (0.25-m² quadrats) and sand shinnery oak mortality was evaluated in December 1986.

Herbicide	Rate	Standing crop Grass	Standing crop Forbs	Western ragweed frequency	Shinnery oak mortality
	(kg ae/ha)	(kg/ha)		(%)	
Control	0.00	1065a[1]	695a	36a	5a
Picloram	0.07	1407abc	118b	11b	13ab
Picloram	0.14	1872c	90b	4b	2a
Picloram	0.28	1474abc	17b	3b	2a
Trichlopyr	0.28	1244ab	196b	10b	62c
Trichlopyr	0.56	1749bc	67b	6b	48c
Picloram + Trichlopyr	0.28+0.28	1937c	50b	3b	43bc

[1]Numbers in the same column followed by the same letter are not significantly different ($P<0.05$).

the 2,4-D plus dicamba treatment appeared little better than the control under these conditions. Picloram, picloram plus 2,4-D, and dicamba most effectively suppressed western ragweed (Table 3). Trichlopyr, which was ineffective when applied during cold air temperatures in 1985, effectively controlled western ragweed in 1986 when applied during warm air temperatures. Grass yields were also highest in the trichlopyr and picloram plus 2,4-D treatments (Table 4). Picloram and dicamba, which gave best weed control (Table 3), provided no more grass than the 2,4-D plots.

Study 4

In Study 1, picloram applied at 0.28 kg ae/ha in 1985 to sand shinnery oak controlled those plants just breaking bud. However, in this study trichlopyr controlled more oak than picloram (Table 5). All herbicides reduced western ragweed ($P<0.05$) compared to unsprayed plots. Also, forb yields were reduced ($P<0.05$) by all herbicide treatments. Grass yields were generally the reverse of forb yields (Table 5).

Conclusions

Many ranchers have successfully used tebuthiuron to control sand shinnery oak on rangeland. However, weedy forb competition often limited post-treatment grass yields far below expectations. Winter weather unfavorable for forb germination makes it unnecessary to consider control efforts most years. But results of this study indicate that even modest weed infestations on sandy rangeland reduce usable forage 560–785 kg/ha. Herbicidal control is warranted in those years favorable for winter weed germination. Our data indicate picloram or dicamba at 0.28 kg ae/ha are usually effective. However, they may cost more than can be recovered in extra benefits if weeds are suppressed for only 1 year. To reduce costs, chemical companies producing these herbicides often combine them with 2,4-D. Our results showed that picloram plus 2,4-D worked reasonably well but we suspect that its effectiveness was due to the picloram alone because of the ineffectiveness of 2,4-D during cool, dry growing conditions. We believe 2,4-D is the most cost-effective alternative under ideal growing conditions of readily available soil moisture and air temperature over 21° C at time of application. If these conditions cannot be met then we suggest using picloram, dicamba, or picloram plus 2,4-D. Trichlopyr was effective if air temperature was over 21° C, even on dry soil. It also suppressed sand shinnery oak more than did picloram.

In 1985 annual and perennial weeds were a problem; by controlling them with picloram we increased grass yield 860 kg/ha. Few annual weeds germinated in 1986, but perennial weeds (mostly western ragweed) produced from 350–795 kg/ha. Grass production increased up to 800 kg/ha if either annual or perennial weedy forbs were controlled. Picloram at 0.28 kg ae/ha allowed increased grass production for 3 years, whereas picloram plus 2,4-D reduced broad-leaved herbaceous weeds sufficiently to increase grass production for 1 year. Since picloram killed sand shinnery oak shoots that were just breaking dormancy, further investigation of this response is warranted.

How many winter weeds should be present before considering control? We found that undesirable annual weeds either were numerous (i.e., all quadrats examined contained seedlings) or they were scarce with few quadrats having seedlings. Herbicidal control would not be needed in the latter case. However, control would be desirable if 1/3–1/2 of the 0.25-m² quadrats examined contained targeted weeds. Fortunately 2 common desirable forbs, erect dayflower and velvet bundleflower, were unharmed by early spring-applied herbicides. They began growth late enough to escape harm.

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