Honey Mesquite Control with Pelleted Hexazinone in Western Texas

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Abstract

Hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(*1H, 3H*)-dione] applied as 1.2 cm^3 (20% ai) pellets in a grid pattern at 2.2 kg active ingredient (ai)/ha killed 11 to 22% of undisturbed honey mesquite *(Prosopis glandulosa* var. *glandulosa)* 26 months after treatment in experiments at 3 locations in western Texas. Honey mesquite plants <1 m tall were less susceptible to grid pattern applications of hexazinone than were larger plants, probably because the smaller plants lacked sufficient root systems to contact herbicide columns in the soil. Efficacy of hexazinone applied in grid patterns for honey mesquite control increased as soil clay and organic matter contents decreased and as the amount of rock increased. Results from a single experiment indicated that hexazinone pellets applied at 0.8 g ai/plant near the stem base killed 48 to 60% of the honey mesquite plants <2 m in height, but this treatment did not control plants >2 m tall.

Honey mesquite *(Prosopis glandulosa* var. *glandulosa)* is a management problem on 22.7 million ha of Texas rangeland (Fisher 1977). The most commonly used herbicide treatments for honey mesquite control have been foliar sprays of 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid] or 1:1 mixtures of 2,4,5-T with picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) or dicamba (3,6-dichloro-2-methoxybenzoic acid) applied at 0.6 to 1.1 kg acid equivalent (ae)/ha. The recent termination of 2,4,5-T production in the United States prompted a search for alternative herbicides. Triclopyr {[(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid} may be effectively substituted for 2,4,5-T alone or in combination with picloram or dicamba for honey mesquite control (Jacoby and Meadors 1983). Clopyralid (3,6-dichloro-2-pyridinecarboxylic acid) is also highly effective for honey mesquite control (Jacoby et al. 1981) but it is not registered for use on rangelands in Texas.

Pelleted formulations of herbicides have effectively controlled several rangeland brush and weed species not susceptible to foliar applications (Scifres 1980, Ueckert et al. 1983). Timing of applications of pelleted herbicides is less restrictive than with foliar sprays, and risk of herbicide drift onto susceptible crops is essentially eliminated (Scifres et al. 1978, Meyer and Bovey 1979, 1980, Scifres 1982). Grid pattern applications of pelleted, nonselective herbicides are intended to minimize damage to shallow-rooted desirable plants and to contact the deeper roots of woody plants (Scifres et al. 1978).

Hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(*1H,3H*)-dione] pellets applied in a systematic grid pattern at 2 to 4 kg ai/ha selectively controlled oaks (*Quercus* spp.) and several associated species in the Post Oak Savannah of eastern Texas (Scifres 1982). Honey mesquite was controlled by grid pattern applications of hexazinone pellets at 2.2 kg ai/ha on a sandy clay loam and at 4.5 kg ai/ha on clay loam soils in the South Texas Plains (Scifres et al. 1984). Broadcast sprays of hexazinone are not feasible for honey mesquite control on rangelands because the herbicide is phytotoxic to forage plants at rates much lower than those effective for mesquite control (Meyer and Bovey 1980).

The short period in spring and early summer when honey mesquite is most susceptible to conventional foliar sprays is a serious constraint to rangeland improvement in Texas. The development of effective pelleted herbicides for honey mesquite control would increase the alternatives available to land managers. The major objectives of this study were to determine the efficacy of pelleted hexazinone applied in a systematic grid pattern (simulated broadcast application) for honey mesquite control in semiarid and arid regions of western Texas, and to relate hexazinone efficacy to selected soil properties. Considerable need also exists for effective individual plant treatments for maintenance control of honey mesquite on rangeland and improved pastures. Thus a secondary objective of this study was to evaluate pelleted hexazinone as an individual plant treatment for honey mesquite control.

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Study Areas

Experiments were established 11 km east of Bakersfield (Pecos County), 10 km north of San Angelo (Tom Green County), and 5 km west of Brady (McCulloch County), Texas. Long-term average annual precipitation is 31 cm at Bakersfield, 47 cm at San Angelo, and 59 cm at Brady. About 75% of the total precipitation typically occurs from April to October at each area. Precipitation records were obtained from the nearest official reporting station or from rain gauges maintained near the sites.

The dominant brush species on all areas was honey mesquite with lesser amounts of lotebush condalia *(Condalia obtusifolia),* agarito *(Mahonia trifoliolata),* and pale wolfberry *(Lycium pallidum).* Additional brush species at Bakersfield were redberry juniper *(Juniperus pinchotii),* tarbush *(Flourensia cernua),* creosotebush *(Larrea tridentata),* and broom snakeweed *(Xanthocephalum sarothrae).* Important grasses at the Bakersfield site were sideoats grama *(Bouteloua curtipendula),* cane beardgrass *(Andropogon barbinodis),* vine mesquite *(Panicum obtusum),* burrograss *(Scleropogon brevifolius),* and red threeawn *(Aristida longiseta).* Dominant grasses at the San Angelo site were sideoats grama, red threeawn, buffalograss *(Buchloe dactyloides),* and tobosa *(Hilaria mutica).* Major grasses near Brady were Texas wintergrass *(Stipa leucotricha),* sideoats grama, red threeawn, and cane beardgrass.

All plots at the Bakersfield site occurred on Iraan silty clay loams (Rives 1980) (Cumulic Haplustolls, 20 to 29% clay, 2.2 to 2.6% organic matter, pH 7.5 to 7.7). Soils at the San Angelo site were Angelo clay loams (Wiedenfeld and Flores 1976) (Torrertic Calciustolls, 28 to 30% clay, 2.4 to 2.5% organic matter, pH 7.7). Dominant soils series at Brady were Owens (Typic Ustochrepts), Tarrant (Lithic Calciustolls), Kavett, Valera, and Mereta (Petrocalcic Calciustolls) (Bynum and Coker 1974) (25 to 38% clay, 2.7 to 3.9% organic matter, pH 7.6 to 7.7).

Methods

Experimental Design and Herbicide Applications

The formulation of hexazinone used in all experiments was the 20% ai pellet, approximately 2.1 by 1.4 by 0.8 cm in size and ellipsoidal in shape. The pellets displaced an average of 1.2 cm^3 of water and weighed an average of 1.87 g.

An experiment was established at each of the 3 study sites to evaluate the efficacy of grid pattern application of hexazinone pellets for control of undisturbed honey mesquite. The experiments were arranged as randomized complete blocks with 2 replications. Plots were 20.1 by 20.1 m with 10-m buffers between plots. Blocks were situated on different soils series where feasible. Hexazinone pellets were applied by hand in grids on 2.6-, 1.8-, or 1.3-m centers to achieve rates of 0.6, 1.1, or 2.2 kg ai/ha, and an untreated check plot was included in each block. These plots were located in honey mesquite stands which had no recent history of disturbance. Grid pattern applications of hexazinone were applied at San Angelo, Brady, and Bakersfield on 28 April, 30 April, and 22 July, 1981, respectively.

A single experiment, also arranged as a randomized complete block with 2 replications, was established at the Brady study area to evaluate the efficacy of hexazinone pellets for control of regrowth honey mesquite. This experiment was established within a dense stand of honey mesquite that had been shredded periodically until 1975. The shrubs were 0.1 to 2.5 m tall and included seedlings, saplings, and multiple-stemmed regrowth. Treatments were applied on 30 April 1981 and were the same as applied in experiments on undisturbed honey mesquite. Plots were 20.1 m by 20.1 m separated by 10-m buffers.

A single experiment to evaluate the efficacy of pelleted hexazinone as an individual plant treatment for honey mesquite control was established at the San Angelo site on 6 May 1981. The experiment was arranged as a completely randomized design with 3 replications. Plot sizes were 20.1 by 20.1 m with 20.1-m buffers between plots. Treatments included hexazinone at 0.4 g ai/plant (1 pellet) and at 0.8 g ai/plant (2 pellets). Pellets were applied by hand near the stem base of each honey mesquite plant in the plots. Three untreated check plots were included in the experiment. This experiment was located in a pasture that had been bulldozed in 1971. The dense stand included single-stemmed seedlings and saplings and multiple-stemmed re-growth. The soil was an Angelo clay loam (26% clay, 2.3% organic matter, pH 7.6).

Evaluation of Defoliation and Mortality

Defoliation and mortality estimates were made at the end of the first and second growing seasons, and during the third growing season after treatment. Honey mesquite trees were stratified into 3 height classes: <1 m, 1 to 2 m, and >2 m. Canopy reduction of honey mesquite plants was visually estimated and the estimates were averaged within height classes for each plot. These plot averages were subjected to statistical analysis. If a honey mesquite plant was completely defoliated with no green shoots, it was considered "apparently dead," and average percent apparent mortality was calculated separately for each height class in each plot. Plot averages were subjected to statistical analyses. Each mesquite plant in the undisturbed honey mesquite plots (grid pattern applications) and in the individual plant treatment experiment were examined. Mesquite densities in the "regrowth" experiment at the Brady site were very high (1,800 to 8,800 plants/ha) so these plots were sampled by examining only those honey mesquite plants within 3.1-m belt transects across the diagonal(s) of each plot.

Percentage canopy reduction and apparent mortality data were transformed by arcsin $\sqrt{p}$, where p = canopy reduction (%) or apparent mortality (%), then subjected to analyses of variance. Means from the transformed data were untransformed for presentation in the tabular data (Kempthorne 1979). Data from the 3 undisturbed honey mesquite experiments were analyzed as a split plot with locations as the whole plot effect and rates as the sub-plot effect. Duncan's multiple range test was used to determine significant differences among means.

Soil Analyses

Two soil samples from each of 2 depths (0 to 15 and 15 to 46 cm) were obtained from each block at each location for laboratory analyses. Soil samples were analyzed in duplicate for percent coarse fraction (material >2 mm), particle-size distribution by the hydrometer method (Day 1965), organic matter content by acid digestion and titration (Allison 1965), and pH measured in 0.01 M $CaCl_2$ (Peach 1965). Weighed averages for percentages of clay, organic matter, and rock for each block were used in regression analyses to determine their relationships to hexazinone efficacy for honey mesquite control. Regression models for mortality of honey mesquite in each height class based on herbicide rate and weighted soil properties were estimated. Additional models based on weighted soil properties were estimated separately for each herbicide rate. Data from the untreated plots were excluded from all regression analyses. Models were selected by the all regressions method (Graybill 1976).

Results and Discussion

Total precipitation received by 30 and 90 days after treatment was 3.8 and 16.6 cm, respectively, at the Bakersfield site; 4.0 and 13.8 cm, respectively, at the San Angelo site; and 5.8 and 18.3 cm, respectively, at the Brady site. Precipitation amounts received the first and second 12-month periods after treatment were 34.1 and 15.7 cm, respectively, at Bakersfield; 61.3 and 60.5 cm, respectively, at San Angelo; and 62.7 and 63.3 cm, respectively, at Brady, which were 110 and 51%, 130 and 128%, and 106 and 107% of the long-term annual averages, respectively, for the 3 locations.

Split-plot analyses of variance on data for undisturbed honey mesquite stands indicated no significant location by rate interaction, thus data from the 3 locations were pooled for presentation. Data on honey mesquite defoliation and apparent mortality at the end of the first growing season after hexazinone application were erratic because of recurring defoliation/refoliation cycles (data not shown). Significant canopy reduction had occurred 16 months after herbicide application on most treated plots but the maximum apparent mortality of undisturbed mesquite on plots treated with hexazinone at the high rate was only 7% (Table 1).

Table 1. Average defoliation (Def.) and mortality (Mort.) (%) of undisturbed honey mesquite 16 months and 26 months after grid pattern applications of pelleted hexazinone at three locations in western Texas.[1]

Height Class	Rate	16 months Def.	16 months Mort.	26 months Def.	26 months Mort.
	(kg/ha)	(%)			
<1 m	0.0	19 c	0 a	24 a	0 b
	0.6	27 bc	2 a	28 a	2 b
	1.1	37 b	5 a	37 a	4 ab
	2.2	52 a	3 a	42 a	11 a
1 to 2 m	0.0	18 c	0 b	30 c	2 b
	0.6	51 b	1 ab	35 c	5 b
	1.1	57 ab	4 ab	51 b	4 b
	2.2	77 a	7 a	66 a	22 a
>2 m	0.0	25 c	0 a	38 c	0 b
	0.6	38 bc	0 a	42 bc	2 b
	1.1	54 b	2 a	53 b	2 b
	2.2	79 a	2 a	72 a	21 a

[1]Means within a column for each height class followed by the same letter are not significantly different by Duncan's Multiple Range Test at the 5% level.

Honey mesquite plants <1 m tall were generally unaffected 26 months after grid pattern applications of hexazinone (Table 1), apparently because the small, young plants lacked sufficient root systems to contact herbicide columns in the soil. Hexazinone at 1.1 to 2.2 kg/ha caused significant defoliation of honey mesquite >1 m tall, but only the high rate caused significant mortality 26 months after treatment (11 to 22%).

Defoliation of regrowth mesquite in the single experiment at the Brady study site (Table 2) was similar to that observed in undisturbed mesquite (Table 1). Hexazinone applied in grid patterns at 0.6 to 2.2 kg/ha caused 31 to 47% apparent mortality of honey mesquite 1 to 2 m tall after 16 months, whereas significant mortality 26 months after treatment occurred only on plots receiving 1.1 or 2.2 kg/ha of hexazinone. Canopies of honey mesquite regrowth >2 m in height were reduced 94% 26 months after application of 2.2 kg/ha of hexazinone but no mortality had occurred in the large regrowth or in plants <1m tall.

Table 2. Defoliation (Def.) and mortality (Mort.) (%) of regrowth honey mesquite 16 and 26 months after grid pattern applications of pelleted hexazinone near Brady, Texas.[1]

Height Class	Rate	16 months		26 months	
		Def.	Mort.	Def.	Mort.
	(kg/ha)	(%)			
<1 m	0.0	11 b	0 a	23 b	0 a
	0.6	34 ab	1 a	23 b	1 a
	1.1	61 a	7 a	56 a	8 a
	2.2	65 a	8 a	77 a	23 a
1 to 2 m	0.0	8 c	0 b	19 b	0 b
	0.6	26 b	31 a	30 b	0 b
	1.1	73 a	32 a	69 a	36 a
	2.2	74 a	47 a	77 a	31 a
>2 m	0.0	4 c	0 a	15 b	0 a
	0.6	16 b	0 a	19 b	0 a
	1.1	58 a	0 a	46 b	0 a
	2.2	76 a	0 a	94 a	0 a

[1]Means within columns and height classes followed by the same letter are not significantly different by Duncan's Multiple Range Test at the 5% level.

Results from the single individual-plant-treatment experiment suggest that hexazinone can kill mesquite plants ≤2 m tall if the herbicide is selectively placed near the stem base (Table 3). Mortality of honey mesquite <1 m and 1 to 2 m tall receiving the 0.8 g ai rate was 48% and 60% respectively, 26 months after treatment. Pelleted hexazinone applied as an individual plant treatment at rates up to 0.8 g/plant did not control mesquite >2 m tall.

Table 3. Defoliation (Def.) and mortality (Mort.) (%) of honey mesquite 16 and 26 months after applications of pelleted hexazinone as individual plant treatments on May 6, 1981 near San Angelo, Texas.[1]

Height Class	Rate	Months post-treatment			
		16 months		26 months	
		Def.	Mort.	Def.	Mort.
	(g ai/plant)	(%)			
<1 m	0.8	46 a	52 a	73 a	48 a
	0.4	41 a	27 a	31 b	33 b
	0.0	18 b	0 b	18 b	0 c
1 to 2 m	0.8	76 a	20 a	52 a	60 a
	0.4	66 a	19 a	41 a	30 ab
	0.0	17 b	0 a	20 a	0 b
>2 m	0.8	65 a	25 a	59 a	20 a
	0.4	25 b	0 a	39 a	0 a
	0.0	22 b	0 a	19 a	0 a

[1]Means within columns and height classes followed by the same letter are not significantly different by Duncan's Multiple Range Test at the 5% level.

Herbicide rate and weighed soil clay content accounted for 65 and 67% of the variation in mortality of small ($P \leq 0.01$) and intermediate sized ($P \leq 0.01$) honey mesquite 26 months after treatment, respectively. Herbicide rate, weighted rock content, and weighed organic matter content explained 83% of the variation in mortality of large honey mesquite ($P \leq 0.01$). Mortality of honey mesquite >2 m tall treated with hexazinone at 1.1 or 2.2 kg/ha was positively related to rock content and negatively related to clay or organic matter content of the soil (Table 4). Mortality of small honey mesquite treated with 1.1 kg/ha was negatively related to clay and organic matter contents.

The relationships of selected soil properties with hexazinone efficacy agree with those reported for soil-active herbicides in general and hexazinone in particular (Beste 1983). Negative relationships of hexazinone efficacy with clay and organic matter occurred because these soil constituents bind hexazinone, leaving

Table 4. Regression models for percentage mortality of honey mesquite 26 months after grid applications of hexazinone at 1.1 or 2.2 kg/ha based on selected soil properties. Data from experiments at three locations were pooled.

Height Class	Model[1]	R^2	P
	1.1 kg/ha		
<1 m	% Mortality = 134.8 – 4.0 CL – 6.4 OM (0.007) (0.014) (0.355)	.85	0.022
>2 m	% Mortality = 25.4 + 0.7 RO – 10.1 CL (0.055) (0.015) (0.040)	.86	0.019
	2.2 kg/ha		
>2 m	% Mortality = 24.4 + 1.6 RO – 9.3 OM (0.092) (0.001) (0.077)	.95	0.003

[1]CL = weighted percentage clay, OM = weighted percentage organic matter, and RO = weighted percentage rock. Regression models for honey mesquite 1 to 2 m tall were not significant. Parenthetical numbers are the significance levels for t-tests for the intercept and coefficients.

less available for root uptake. Duncan and Scifres (1983) found activity of soil-applied tebuthiuron {*N*-[5-(1,1-dimethylethyl 1,3,4-thiadiazol-2-yl]-*N*-*N'*-dimethylurea} inversely related to clay and organic matter contents in 10 different rangeland soils in a greenhouse study. Positive relationships of hexazinone efficacy with percent rock content of soils can be explained by the reduced volume of soil colloids in the presence of rocks, which resulted in a higher concentration of hexazinone in the available soil water solution.

Hexazinone killed all herbaceous plants within 15 to 30 cm of each pellet and these areas were generally bare in most plots after 26 months. These spots were recolonized by herbaceous plants 2 to 3 years after hexazinone pellets were applied in areas receiving more rainfall (Meyer and Bovey 1980, Scifres 1982).

Grid pattern applications of hexazinone pellets at rates up to 2.2 kg/ha did not control undisturbed or regrowth honey mesquite as satisfactorily as is usually attained with properly timed applications of foliar sprays of 2,4,5-T or mixtures of 2,4,5-T with picloram or dicamba. Foliar sprays usually cause 90% or greater defoliation and 20 to 50% mortality of honey mesquite (Jacoby and Meadors 1983). Data from a single experiment suggest that hexazinone may be useful as an individual plant treatment for honey mesquite seedlings or saplings ≤2 m in height. A liquid formulation of hexazinone was registered for use as an individual plant treatment for control of honey mesquite and other undesirable shrubs on Texas rangelands in January 1983. Our data also suggest that hexazinone may be most effective for controlling honey mesquite on soils with low clay and organic matter contents and on rocky soils. However, caution should be exercised in extrapolating results of our regression analyses to other environments because these equations were estimated from a small data set.

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