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Granular Herbicides for Woody Plant Control[1]

R. W. Bovey, H. L. Morton, J. R. Baur, J. D. Diaz-Colon, C. C. Dowler,[2] and S. K. Lehman[3]

Abstract. Granular 4-amino-3,5,6-trichloropicolinic acid (picloram) was effective in controlling live oak *(Quercus virginiana* (Mill.), huisache) *(Acacia farnesiana* (L.), Willd.), and yaupon *(Ilex vomitoria* Ait.), but not honey mesquite *(Prosopis juliflora* (Swartz) DC. var. *glandulosa* (Torr.) Cockerell) in south Texas. Granular 5-bromo-3-*sec*-butyl-6-methyluracil (bromacil) controlled live oak and huisache. Herbicides applied to soil were usually most effective in spring and fall during periods of active brush growth. Picloram granules applied in May to a mixed stand of woody plants in Puerto Rico usually were effective. However, rates up to 30 lb/A were ineffective on some species.

Introduction

An effective method of thinning commercial forests, and of killing brush, is needed to achieve maximum utilization of forest and rangelands. Darrow and McCully (3) studied the use of pelleted 1,1-dimethyl-3-phenylurea (fenuron) for control of brush in east Texas. Aerial applications of fenuron at 4 lb/A from February to the middle of May produced effective control of post oak *(Quercus stellata* Wangh.), blackjack oak *(Quercus marilandica* Muenchh.), and winged elm *(Ulmus alata* Michx.). Hazards of chemical drift were greatly reduced as compared to spray applications.

Previous research has shown that soil applications of 4-amino-3,5-6-trichloropicolinic acid (picloram) effectively controlled greenhouse-grown huisache *(acacia farnesiana* (L.) Willd.) plants (1). Field research in Texas (2), Alabama (6), and Puerto Rico (4) indicated that soil or foliar spray applications of picloram killed a wide variety of woody plants. Meyer and Riley (5) found picloram sprays generally more effective than granules for control of whitebrush *(Aloysia lycioides* Cham.) on the Edwards Plateau in Texas. However, granules were effective during the cooler months, particularly when application was followed by rainfall.

This study was conducted to determine the effectiveness of picloram, fenuron, and 5-bromo-3-*sec*-butyl-6-methyluracil (bromacil) granules for the control of live oak *(Quercus virginiana* Mill.), huisache *(Acacia farnesiana* (L.) Willd.), honey mesquite *(Prosopis juliflora* (Swartz) DC. var. *glandulosa* (Torr.) Cockerell), and yaupon *(Ilex vomitoria* Ait.) in Texas, and of a mixed forest in Puerto Rico.

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[2]Agronomists, Plant Physiologists, and Agricultural Research Technician, Crops Research Division, Agr. Res. Ser., U.S. Dep. of Agr., College Station, Texas. Present address of H. L. Morton is 2000 East Allen Road, Tucson, Arizona and that of C. C. Dowler is Coastal Plain Experiment Station, Tifton, Georgia.

[3]Formerly Instructor, Department of Range Science, Texas A&M University, College Station, Texas; now Plant Physiologist, Agricultural Chemistry Laboratories, Hercules Inc., Wilmington, Delaware.

Materials and Methods

We applied granular herbicides to soils at Victoria, Refugio, Campbellton, Bryan, and College Station, Texas, supporting stands of live oak, huisache, honey mesquite, and yaupon. We also applied granular herbicides to a mixed forest at Mayaguez, Puerto Rico. Wild coffee *(Casearia sylvestris* Sw.), white wood *(Ocotea leucoxylon* (Sw.) Mez), Dominican mahogany *(Swietenia mahogoni* Jacq.), pomarrosa *(Eugenia jambos* (L.) Stokes), and pink trumpet tree *(Tabebuia heterophylla* (DC.) Britton) were the most abundant species. Herbicides and rates for each location are given later.

Granular herbicides included 2, 4, and 25% active ingredient of picloram, bromacil, and fenuron, respectively. Pellets of 10% active ingredient of picloram were applied in Puerto Rico. Herbicides were broadcast on the plots by hand or by a hand-carried mechanical spreader at all locations. Other herbicide placement methods were included at the Bryan, Texas location and are explained later.

Plot size in Texas was usually 1 or 2 sq rd with three replications arranged in a randomized block design. The yaupon plots (Texas) and mixed forest (Puerto Rico) were 50 by 50 ft and 66 by 66 ft, respectively. The soil at the Puerto Rican site was Nipe clay, lateritic, well drained, highly permeable, and low in fertility. Annual rainfall was 80 to 100 inches.

At Victoria (Gulf Prairie), a dense stand of live oak 3 to 6 ft in height was used. The Katy gravelly sandy loam soil was moderately well drained, with a varying quality of gravel in the lower profile. Annual rainfall averaged 30 to 32 inches. The Refugio site contained huisache and honey mesquite 2 to 8 ft tall when treated. The soil was a Miguel fine sandy loam, shallow phase; the subsoil was slowly permeated. Mean annual precipitation was 30 to 32 inches.

At Campbellton the soil was Montesola, dark gray to dark grayish brown, with a crumbly calcareous clay surface 15 to 20 inches thick. The subsoil was a gray compact calcareous clay. Plots were on a gentle south slope. Brush was predominantly huisache. Annual rainfall was 25 to 27 inches.

Huisache, 8 to 12 ft tall, was treated in the woody plant nursery, Texas A&M University Research Annex, Bryan, Texas. Plots were 12 ft wide with huisache planted lengthwise in the center in a row. Plot length was 60 ft with at least 10 plants in each plot. Herbicide placement included (a) broadcast application over the entire plot; (b) broadcast application over one-half of the plot (6-ft strip along one side of the row); and (c) individual placement of granules around the base of each plant.

Herbicide rates for the Bryan site were ½, 2, and 4 lb/A based on the area of the entire plot. Active ingre-

dient of picloram per tree was 3.8, 15.0, and 30.0 g for the ½, 2, and 4 lb/A rates for individual tree treatments, respectively. The soil was primarily Erving clay loam, which is slowly permeated by water. Annual rainfall was 38 to 40 inches.

The yaupon site was located near College Station on Gowen soil which is a dark grayish-brown sandy loam surface over a neutral clay loam subsoil. It has a slightly acid to neutral reaction. The soil was moderately well drained and received 38 to 40 inches of rainfall annually.

Herbicide effectiveness was determined at all locations by using ocular estimates of the percentage canopy reduction of brush in each plot.

Results and Discussion

Preliminary studies. At equal dosages, picloram was more effective than fenuron on live oak, huisache, and honey mesquite. Reduction of brush increased as herbcide rates increased (Table 1). We consider a 90% or more canopy reduction of the woody species included in this paper as the acceptable level of control 1 or more years after a single application of herbicide. Picloram at 5 lb/A killed all the huisache. Rates of either fenuron or picloram up to 10 lb/A did not satisfactorily control honey mesquite (Table 1). Likewise, fenuron or picloram did not control honey mesquite when applied May 11, 1965.[4]

Table 1. Percentage canopy reduction of live oak at Victoria, Texas, and huisache and honey mesquite at Refugio, Texas, after treatments of picloram and fenuron granules October 12, 1964.[a]

Treatment		Time after application (years)					
		Live oak		Huisache		Honey mesquite	
Herbicide	lb/A	1	2	1	2	1	2
Fenuron	1	0	0	10	65	0	0
Fenuron	2	10	0	30	50	0	30
Fenuron	5	25	5	70	88	50	20
Fenuron	10	73	48	85	83	40	4
Picloram	1	20	5	55	75	0	0
Picloram	2	50	30	75	85	20	20
Picloram	5	78	58	100	100	30	5
Picloram	10	93	88	100	98	80	20

[a]Rainfall in inches 2 weeks before and 2 weeks after treatment = 0 and 0.3 at Victoria; 0 and 1.5 at Refugio.

Huisache. Picloram granules at rates of 2 lb/A and higher were effective in controlling huisache after spring and fall applications at Refugio and Campbellton, Texas (Table 2). Picloram was more effective than fenuron at rates up to 10 lb/A. Ten lb/A of either herbicide killed all plants by 2 years after treatment. Huisache was killed when at least 4 lb/A of picloram was applied, regardless of treatment date. Since most treatments were effective, lethal amounts of the herbicide apparently were leached into the soil and absorbed by huisache roots.

Treating the soil around individual huisache plants was usually more effective than broadcast treatments (Table 3). Spreading granules over the entire plot, however, was more effective than treating the plot on one side of the plant (half of the root system). The ½ and 2-lb/A rates of picloram usually were not effective when applied to the soil in the woody plant nursery, whereas 2 lb/A were effective at Refugio and Campbellton (Tables 2 and 3). The heavy Erving clay loam soil at the nursery site may have adsorbed more of the picloram than the lighter soils at other locations, making less herbicide available for uptake by huisache. Spring (May and June), summer (August), and fall (October) usually were more effective than late fall, winter, and early spring (November, February, and March) treatments. Picloram granules applied in April were more effective than when applied in March, suggesting that actively growing plants are necessary for successful control. Rainfall usually was sufficient for herbicidal success at most dates of application.

Table 2. Percentage canopy reduction of huisache at Refugio and Campbellton, Texas, after spring and fall treatments of granular picloram.

Location	Date of treatment	Rainfall, inches[a]		Treatment		Time after treatment (years)	
		Before	After	Herbicide	lb/A	1	2
Refugio.....	5-11-65	0	2.7	Picloram	1	43	60
					2	55	75
					3	60	35
					4	100	100
					5	100	100
					10	100	100
				Fenuron	1	0	10
					2	30	15
					5	63	35
					10	98	100
	11-2-65	0.7	3.0	Picloram	2	93	83
					4	92	90
					6	82	87
					8	97	100
	4-27-66	6.8	3.2	Picloram	2	75	93
					4	95	77
					6	97	100
					8	100	100
Campbellton	11-2-65	0	1.7	Picloram	2	87	92
					4	100	100
					6	100	100
					8	100	100
	4-28-66	3.3	2.8	Picloram	2	100	95
					4	100	100
					6	100	100
					8	100	100

[a]Inches of rainfall 2 weeks before and 2 weeks after treatment.

Table 3. Percentage canopy reduction of huisache 1 year after treatment with three rates of granular picloram using three placement methods at nine dates of application at Byran, Texas.

Herbicide placement	Picloram lb/A	Date of application[a]								
		Oct 1966	Feb 1967	Mar 1967	May 1967	Aug 1967	Nov 1967	Feb 1968	Apr 1968	June 1968
Inches of rainfall 2 wks before treatment & 2 wks after treatment		0.1 2.2	0.6 1.0	0 1.8	0 6.0	1.3 0.4	0.9 0.2	1.4 1.1	3.7 2.1	4.3 8.3
Individual	½	17	0	0	3	17	0	0	7	0
Individual	2	88	15	37	63	33	0	33	33	93
Individual	4	100	87	63	100	92	73	67	80	87
Half-broadcast	½	0	0	0	0	0	0	5	7	0
Half-broadcast	2	12	0	0	13	27	0	27	27	47
Half-broadcast	4	63	13	15	73	83	33	87	67	57
Broadcast	½	7	3	0	3	—	0	0	0	0
Broadcast	2	40	0	0	18	60	30	13	40	83
Broadcast	4	97	7	40	85	93	43	53	87	98

[a]Evaluations were made 6 months after treatment for treatments applied in February, April, and June 1968; all others were for 1 year after treatment.

Live oak. Live oak in the treatment area occurred as a dense shrub stand; consequently, only broadcast applications were made. Bromacil applied in the spring as a soil treatment appeared effective (Table 4). Poor control

[4]Unpublished data.

Table 4. Percentage canopy reduction of live oak by spring and fall treatments near Victoria, Texas.

Date of treatment	Rainfall, inches[a]		Treatment		Time after treatment (years)		
	Before	After	Herbicide	lb/A	1	2	3
5-12-65.....	0.1	3.2	Picloram	2	68	53	25
				3	68	58	45
				4	60	48	20
				5	90	53	33
				10	98	93	93
			Fenuron	2	80	50	50
				5	85	75	70
				10	95	65	55
			Bromacil	2	98	93	90
				4	100	100	100
				8	100	99	100
11-2-65.....	2.5	2.1	Picloram	2	67	63	10
				4	88	85	48
				6	99	95	92
				8	93	94	80
			Bromacil	2	13	0	5
				4	74	40	50
				6	75	62	63
				8	100	88	95
			Picloram + Bromacil	1+1	27	18	5
				2+2	73	70	37
				3+3	86	78	67
				4+4	97	92	88

[a]Inches of rainfall 2 weeks before and 2 weeks after treatment.

was obtained when the same rate was applied in the fall. Combinations of picloram plus bromacil were not effective until rates of 8 lb/A of the mixture was reached. At rates above 2 lb/A, bromacil and picloram applied in the fall were similar in effectiveness for control of live oak.

Studies comparing dates of application for control of live oak with spray and granular formulations of picloram and bromacil are shown in Table 5. Picloram was

Table 5. Percentage canopy reduction of live oak 1 year after herbicidal treatment at seven dates of application at Victoria, Texas.

Treatment		Date of treatment							
Herbicide[a]	lb/A	May 1966	June 1966	Sept 1966	Feb 1967	Apr 1967	May 1967	June 1967	Mean[b]
Inches of rainfall 2 wks before treatment & 2 wks after treatment		4.8 0.2	1.3 2.3	0.6 1.4	0.9 0.1	1.6 0.7	0.6 1.8	0 0.2	
Picloram (S)	3	97	94	98	73	95	92	83	90 ab
Picloram (G)	3	98	97	86	43	95	95	87	86 b
Picloram (S)	6	99	98	100	93	95	97	93	97 a
Picloram (G)	6	99	99	83	57	97	95	93	89 ab
Bromacil (S)	3	57	62	40	48	67	47	23	49 d
Bromacil (G)	3	80	88	98	3	87	78	78	73 c
Bromacil (S)	6	91	96	88	67	90	75	78	84 b
Bromacil (G)	6	97	94	95	42	95	97	87	87 b
Mean[b]		90 a	91 a	86 a	53 d	90 a	85 ab	78 c	

[a]S = spray; G = granular formulation.
[b]Values followed by the same letter do not differ at the .05 level of significance.

generally more effective than bromacil. Picloram sprays and granules usually were not significantly different, although granules were less effective during September and February. Bromacil granules, however, were more effective than sprays at 3 lb/A. At 6 lb/A, there were no differences between bromacil granules and sprays. Control was poor when the herbicides were applied in February.

Yaupon. Picloram and fenuron granules at 1, 2, and 4 lb/A applied in April 1966, reduced percentage canopy cover of yaupon 59, 86, 91 and 51, 58, 65%, respectively, 1½ years after treatment. Picloram was more effective than fenuron. Rainfall 2 weeks before and 2 weeks after treatment was 0.54 and 1.01 inches, respectively.

Mixed forest. Rates as high as 30 lb/A of picloram failed to defoliate and kill all woody species in a Puerto Rican mixed forest (Table 6). The most effective date of appli-

Table 6. Response of a mixed forest at Mayaguez, Puerto Rico, to pellets of picloram 6 months after treatment.

Date of treatment	Rainfall, inches		Picloram lb/A	Percent canopy reduction
	Before	After		
5-15-67.....	6.08	3.11	5	87
			10	83
			15	84
			30	96
8-15-67.....	3.80	3.95	5	77
			10	86
			15	85
			30	79
10-30-67.....	5.39	2.15	5	36
			10	64
			15	62
			30	77

cation was May. Species resistant to picloram included pomarrosa, Santa Maria (*Calophyllum brasiliense* (Camb.), coco-plum (*Chrysobalanus icaco* L.), and fiddlewood (*Petitia domingensis* Jacq.). Moderately susceptible and susceptible species included: pink trumpet tree, mango (*Mangifera indica* L.), whitewood, Dominican mahogany, camasey (*Miconia prasina* (Sw.) DS.), bay rum tree (*Pimenta racemosa* (Mill.) J. W. Moore), candlewood tree (*Cupania americana* L.), mamee apple (*Mammea americana* L.), West-Indian locust (*Hymenaea courbaril* L.), and wild coffee.

Formulation comparison. At equal rates, spray formulations of picloram usually are slightly more effective than granules on huisache and live oak (Table 7). Spring and

Table 7. Percentage canopy reduction of huisache, live oak, honey mesquite, and yaupon 1 and 2 years after herbicide sprays and granules at six locations in Texas.

Species	Location	Date of application	Herbicide	lb/A	Formulation and time after treatment (years)			
					Granular		Sprays	
					1	2	1	2
Huisache	Refugio	Oct 1964	Picloram	1	55	75	60	68
				2	75	85	95	93
		May 1965		1	43	60	73	38
				2	55	75	95	85
	Campbellton	Nov 1965		2	87	92	90	93
	Bryan (Nursery)	Oct 1966		2	40	—	100	—
		May 1967		2	18	—	100	—
Live oak	Victoria	Oct 1964		2	50	30	83	50
		May 1965		2	68	53	50	20
				4	60	48	93	78
			Bromacil	4	100	100	58	55
		Nov 1965	Picloram	2	67	63	94	79
				4	88	85	98	96
Honey mesquite	Refugio	Oct 1964		1	0	0	0	0
				2	20	20	0	0
		May 1965	Picloram	1	5	0	85	50
				2	5	0	98	90
Yaupon	College Station	Apr 1965		2	—	86	—	85

fall applications of granular picloram were not effective on honey mesquite, whereas spray applications made in the spring were effective. Granular bromacil was more effective than equal rates of bromacil spray on live oak.

Granular herbicides are effective in controlling brush and usually are most effective during spring and fall months and during periods of active growth by the woody

plants. For best results, adequate rainfall after application is necessary in order to leach the herbicide into root areas. Rainfall usually was not a limiting factor in our studies, but may affect herbicide efficiency in lower rainfall areas. Bromacil was more injurious to forage species than picloram or fenuron. Grasses such as little bluestem *(Andropogon scoparius* Michx.) grew abundantly in areas treated with picloram.

Granular herbicides may be applied during adverse weather conditions, may reduce the drift hazard, require no elaborate application equipment (can be dispersed by hand), and can be applied over a longer period of time for effective brush control. Disadvantages of granular formulations are that higher rates may be required for effective control, they may require excess storage space, and more bulk must be transported and applied.

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