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Effect of hand defoliation on herbicide efficacy in honey mesquite

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Abstract

Greenhouse and field experiments were conducted to evaluate the effect of hand defoliation of honey mesquite (*Prosopis glandulosa* Torr) before herbicide application on herbicide efficacy. In the greenhouse, the monoethanolamine salt of clopyralid, the butoxyethyl ester of triclopyr, and 1:1 mixtures of clopyralid plus triclopyr were applied as foliar sprays at 140 g ha^{-1} each on 2-year-old single-stemmed plants averaging 50 cm tall. In the field, the same. herbicides were applied as broadcast sprays at rates of 280 g ha^{-1} on multistemmed trees 1 to 2 m tall. Plants were defoliated prior to herbicide application at 0, 25, and 50% of original foliage. Defoliation at 25 or 50% did not reduce herbicide efficacy compared to nondefoliated plants in the greenhouse or field. The clopyralid:triclopyr mixture was sometimes synergistic in controlling honey mesquite in the greenhouse and field.

Resumen

Se realizaron ensayos de campo e invernadero para evaluar la eficacia de herbicidas en mesquite (*Prosopis glandulosa* Torr.) luego de una defoliación manual. Plantas de dos años de edad, tallo simple y 50 cm de altura promedio fueron tratadas en invernadero (rociado foliar; 140 g ha^{-1}) con mono-etanol-amina de clopyralid, butoxi-etil-ester de triclopyr y una mezcla 1:1 de clopyralid y triclopyr. Los mismos herbicidas fueron rociados en condiciones de campo sobre árboles de 1 a 2 m de altura y tallos múltiples a razón de 280 g ha^{-1}. Las plantas fueron defoliadas antes de la aplicación de herbicida a 0, 25 y 50% del follaje original. Tanto a campo como en invernadero, defoliaciones de 25 y 50% no redujeron la eficacia del herbicida en comparación con plantas no defoliadas. La mezcla clopyralid:triclopyr exhibió algún sinergismo en el control de mesquite en invernadero y a campo.

Key Words: clopyralid, triclopyr, *Prosopis glandulosa*;

Honey mesquite (*Prosopis glandulosa* Torr.) is an important woody legume and a significant weed problem in southwestern U.S. rangelands (Jacoby and Ansley 1991). The monoethanolamine salt (MEA) of clopyralid (3,6-dichloro-2-pyridinecarboxylic acid) and the butoxyethyl ester (BEE) of triclopyr {[(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid} mixed at low rates is one of the most effective hormone-like herbicide treatments available for control of honey mesquite (Bovey and Whisenant 1991, 1992). The 1:1 mixture of clopyralid:triclopyr produces a synergistic response.

Clopyralid applied alone as a foliar spray is the most effective herbicide for late summer or fall treatment, provided there is sufficient leaf cover to intercept and absorb the herbicide (Meyer and Bovey 1986, Bovey and Meyer 1987, Jacoby et al. 1991). When control of honey mesquite was obtained in fall applications (Meyer and Bovey 1986), clopyralid concentrations were high in upper and basal stem phloem and xylem (Bovey et al. 1986).

When applied as foliar sprays, addition of triclopyr, picloram or surfactants to clopyralid spray solutions enhanced its absorption into leaves by 4 hours after treatment and enhanced its movement into the upper stem phloem by 1 day after treatment (Bovey et al. 1988a). There is strong evidence that optimal uptake of clopyralid in honey mesquite is through leaves but not stems or roots. Leaves absorbed high amounts of foliar applied clopyralid, as indicated by concentrations of 10 μg g^{-1} fresh wt or more in basal stem phloem by 4 days after treatment (Bovey et al. 1988b). Small quantities of clopyralid (<1 μg g^{-1}) were detected in basal stem phloem after spray applications of clopyralid to defoliated plants or roots treated by soil application. When applied to foliated plants, clopyralid killed 60% or more plants, but none were killed when clopyralid sprays were applied to defoliated plants or when 2.2 kg ha^{-1} of clopyralid were applied to the soil.

Current suggested application time for clopyralid and/or triclopyr is late spring to midsummer after leaves have turned dark green and soil temperature reaches 24° C at 30 cm deep (Welch 1995). Few data are available on the response of honey mesquite to herbicides after plants become partially defoliated. Natural events such as drought, insect or hail damage, grazing by livestock or wildlife may cause partial defoliation.

The objective of this study was to determine the influence of partial hand defoliation of honey mesquite on the efficacy of clopyralid, triclopyr, and clopyralid:triclopyr mixtures applied as foliar sprays to greenhouse-grown and natural stands of honey mesquite using conventional spray application techniques in late spring to midsummer applications. We hypothesized that because foliage appears to be the main route of clopyralid entry, that a reduction in foliage should reduce herbicide uptake and subsequent activity.

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Materials and Methods

Greenhouse Experiment

Honey mesquite plants were grown from seed in the greenhouse in pots (12.7-cm in diameter and depth) containing a mixture of Bleiberville clay (fine montmorillonitic Udic Pellusterts), sand, and peat moss 1:1:1 by vol. from March 1991 to May 1993. Daytime temperature was 30 to 35° C, and night temperature was 20 to 25° C. Day length averaged 14 hours during the experiment with 800 $\mu E\ m^{-2}sec^{-1}$ photosynthetically active radiation (PAR) at midday during sunlight. Two plants were grown per pot, and each had a single woody stem with an average height of 50 cm and 15 leaves $plant^{-1}$ when treated in May 1993. Pots were watered daily. A commercial fertilizer (13-13-13) was applied at 0.8 g per pot every 6 wk.

Immediately before herbicide application plants were defoliated by clipping the appropriate leaf petiole near the main stem. For the 25% defoliation, every fourth leaf was removed by severing the petiole close to the main single stem the length of the stem. The 50% defoliation removed every other leaf from the stem. The controls had no defoliation.

Foliar sprays of the MEA of clopyralid or the BEE of triclopyr were applied alone at 140 g ha^{-1} or in mixtures at 140 g ha^{-1} each. Applications were made in water diluent in a laboratory spray chamber at an equivalent spray volume of 93 liter ha^{-1} (Bouse and Bovey 1967) to pots containing 2-yr-old honey mesquite. Surfactant X-77 (alkylarylpolyethylene glycol, free fatty acid, and isopropanol) was added at 0.1% by vol. of the spray solution. Rates of herbicide were selected to bracket 50% kill of stem tissue (Bovey and Whisenant 1991). Plants were returned to the greenhouse after treatment in mid- or late May 1993 and watered after 24 hours and daily thereafter.

Three months after spraying, the response of treated plants to herbicides was evaluated by visually estimating percentage of dead stem tissue on each plant. Plants with no live stem tissue and no regrowth were considered dead. Five replicates (pots) were used in a randomized complete block design. Data were subjected to analysis of variance and means were compared using Fisher's Protected LSD at the 5% level. The experiment was repeated and the data were pooled because the date by treatment interaction was not significant.

Field Experiments

Honey mesquite plants 1 to 2 m tall growing in a Wilson clay loam (fine, montmorillonitic, thermic Vertic Ochroaqualfs) near Bryan, Tex., grew vigorously, usually multistemmed, on an area mowed several years before. Plants were numbered with metal tags in groups of 5 for each of 3 replicates. Plants were >1 m apart within the groups arranged in a randomized complete block design. Plants were sprayed between 0600 and 0800 hours with air temperatures of 25 to 30° C and relative humidity of 90 ± 5%. Spraying ceased at wind velocities of 5 km $hour^{-1}$.

Within 48 hours before herbicide application each hand defoliated tree had 25 or 50% of the leaves removed from the entire plant. When defoliated 25%, every fourth leaf was removed by severing the petiole close to each stem the length of the stem. The 50% defoliation removed every other leaf on each stem. Nondefoliated trees were fully foliated and showed no evidence of natural defoliation from drought or insect damage.

Foliar broadcast sprays of the MEA of clopyralid or the BEE of triclopyr were applied alone at 280 g ha^{-1} or in mixtures at 280 g ha^{-1} each. On each honey mesquite tree, applications were made with a hand-carried 3 nozzle boom sprayer in water diluent at 190 liter ha^{-1} operated at a pressure of 210 kPa. Applications were made in 1993 and 1994 in mid-June and mid-July. Two locations were used in 1993 separated by about 3 km. The entire experiment was repeated in 1994 at only one location.

Herbicide treatments were visually evaluated after 1 yr by estimating percent canopy reduction and mortality of each tree. Trees were considered dead if they were completely defoliated and had no living tissue or resprouts. Canopy reduction and mortality data were subjected to analysis of variance. Means were separated by Fisher's Protected LSD Test at the 5% level. Data for the July experiments were presented separately due to the significant treatment by location interaction.

Results and Discussion

Greenhouse Experiment

Herbicide activity on honey mesquite was not reduced after 25 or 50% leaf removal before herbicide treatment compared to foliated plants (Table 1). Clopyralid killed 22% of the stem tissue with foliated plants and 17% when 50% of the leaves were removed before spraying. Triclopyr was equally effective as clopyralid except when 50% of the leaves were removed and 53% of the stem tissue was killed. More stem tissue was killed with both herbicides when 25% of the leaves were removed compared to foliated plants. Possibly leaf defoliation at 25% improved coverage and penetration of the herbicide sprays into the canopy and resulted in greater exposure and retention of the herbicide on plant surfaces.

Table 1. Percent dead stem tissue of 2-year-old greenhouse-grown honey mesquite 3 months after foliar application of clopyralid, triclopyr and 1:1 clopyralid:triclopyr mixture on plants receiving 3 hand defoliation treatments immediately before herbicide application.

Herbicide[1]	Hand defoliation	Dead stem tissue
	(%)	
Clopyralid	0	22
	25	47
	50	17
Triclopyr	0	32
	25	61
	50	53
Clopyralid + Triclopyr	0	100
	25	97
	50	90
Untreated	0	1
$LSD_{(0.05)}$		18

[1]Herbicides applied at 140 g ha^{-1} each alone or in mixture as the monoethanolamine salt of clopyralid and the butoxyethyl ester of triclopyr in mid- and late May 1993. Data pooled for 2 experiments.

By mixing clopyralid and triclopyr at 140 g ha^{-1} each, the high percentage of dead stem tissue indicated the synergistic activity of these 2 herbicides (Table 1). Synergism is the phenomenon whereby the effect of 2 substances acting together is greater than the sum of their individual effects. Clopyralid plus triclopyr

Table 2. Percent canopy reduction and mortality of 1 to 2 m tall honey mesquite trees 1 year after foliar application of clopyralid, triclopyr and 1:1 clopyralid:triclopyr mixture on plants receiving 3 hand defoliation treatments immediately before herbicide application.

Herbicide[1]	Hand defoliation	Honey mesquite control	
		Canopy reduction	Mortality
	(%)		
Clopyralid	0	88	47
	25	90	62
	50	83	49
Triclopyr	0	54	7
	25	49	7
	50	55	13
Clopyralid + Triclopyr	0	95	59
	25	98	87
	50	96	76
Untreated	0	4	0
	25	5	0
	50	4	0
$LSD_{(0.05)}$		8	26

[1]Herbicides applied at 280 g ha^{-1} each alone or in mixture as the monoethanolamine salt of clopyralid and the butoxyethyl ester of triclopyr at 3 locations in June 1993 and 1994.

killed all stem tissue with no hand defoliation and 90% or more when hand defoliated. The data support previous reports regarding the synergistic action of clopyralid plus triclopyr (Bovey and Whisenant 1991, 1992).

Field Experiments

Similar to greenhouse-grown plants, efficacy of mid-June applications of clopyralid and triclopyr were not reduced on field-grown trees when defoliated at 25 or 50% (Table 2). Clopyralid alone at 280 g ha^{-1} caused 88% canopy reduction and killed 47% of the foliated plants. When defoliated by 50%, clopyralid produced 83% canopy reduction and 49% mortality. Combining clopyralid plus triclopyr increased percent canopy reduction and mortality over the sum of both herbicides applied alone, but was not significantly different than clopyralid applied alone. Greater mortality was obtained when 25% of the leaves were removed compared to no defoliation with clopyralid plus triclopyr. Triclopyr at all levels of hand defoliation reduced the canopy about 50% with <14% mortality.

When applied in mid-July, clopyralid caused more canopy reduction than triclopyr at locations 1 and 2 but not location 3 (Table 3). Less than normal rainfall in July 1994 may have influenced results at location 3 (Table 4). Abundant rainfall in June 1993 at location 1 and 2 may have provided a more favorable environment for herbicide activity in July 1993 compared to July 1994. At location 1, clopyralid plus triclopyr was no more effective than clopyralid applied alone but was significantly more effective than triclopyr applied alone. At location 2 the mixture was more effective than either herbicide applied alone but was not synergistic. At location 3 when hand defoliated at 25 and 50%, the mixture was more effective than either herbicide

Table 3. Percent canopy reduction of 1 to 2 m tall honey mesquite trees 1 yearr after foliar application of clopyralid, triclopyr and 1:1 clopyralid:triclopyr mixture on plants receiving 3 hand defoliation treatments immediately before herbicide application.

Herbicide[1]	Hand defoliation	Honey mesquite control		
		Location 1	Location 2	Location 3
	(%)			
Clopyralid	0	73	71	27
	25	79	75	15
	50	74	79	23
Triclopyr	0	19	45	25
	25	19	51	30
	50	37	46	19
Clopyralid + Triclopyr	0	78	100	35
	25	89	99	60
	50	75	99	60
Untreated	0	2	10	1
	25	9	11	2
	50	4	12	2
$LSD_{(0.05)}$		17	17	24

[1]Herbicides applied at 280 g ha^{-1} each alone or in mixture as the monoethanolamine salt of clopyralid and the butoxyethyl ester of triclopyr at location 1 and 2 in July, 1993 and location 3 in 1994.

Table 4. Rainfall near the experimental sites from 1 Jan. 1993 to 30 Dec. 1994.[1]

Month	1993		1994	
	Rainfall	Dev. from normal	Rainfall	Dev. from normal
	(cm)			
January	15.27	8.28	6.05	-0.69
February	5.03	0.42	6.83	0.18
March	11.71	5.16	5.79	-0.76
April	9.80	1.22	4.42	-4.17
May	18.44	6.25	13.92	1.73
June	28.24	18.90	9.30	-0.05
July	0.00	-5.82	0.28	-5.54
August	0.20	-5.94	12.73	6.58
September	5.81	-7.19	9.50	-2.87
October	12.60	2.92	47.68	m
November	7.70	0.30	2.18	-5.82
December	6.09	-1.12	27.23	20.04
Total	120.24	20.98	145.90	m

[1]Data taken from "Climatological Data" U.S. Dep. Commerce, Nat.Climatic Center, Fed. Bldg., Ashville, N.C. as collected at College Station, Tex.

Table 5. Percent mortality of 1 to 2 m tall honey mesquite trees 1 year after foliar application of clopyralid, triclopyr and 1:1 clopyralid:triclopyr mixture on plants receiving 3 hand defoliation treatments immediately before herbicide application.

Herbicide[1]	Hand defoliation	Honey mesquite control		
		Location 1	Location 2	Location 3
	(%)			
Clopyralid	0	33	13	0
	25	40	20	0
	50	27	33	7
Triclopyr	0	0	0	0
	25	0	0	0
	50	7	0	0
Clopyralid + Triclopyr	0	33	100	0
	25	53	93	13
	50	27	93	20
Untreated	0	0	0	0
	25	0	0	0
	50	0	0	0
$LSD_{(0.05)}$		30	29	13

[1]Herbicides applied at 280 g ha^{-1} each alone or in mixture as the monoethanolamine salt of clopyralid and the butoxyethyl ester of triclopyr at location 1 and 2 in July, 1993 and location 3 in 1994.

applied alone. Hand defoliation did not reduce percent canopy reduction of honey mesquite in any herbicide treatment.

Mortality of honey mesquite was not reduced by hand defoliation in any herbicide treatment or location (Table 5). At location 2 the herbicide mixture was synergistic and killed 93% or more of the plants regardless of hand defoliation level. Mortality was very low in all herbicide treatments at location 3 but defoliation prior to spraying increased mortality if treated with clopyralid plus triclopyr. Typically clopyralid and especially triclopyr decline in effectiveness on honey mesquite in mid- to late July compared to earlier treatments (Meyer and Bovey 1986). Herbicide efficacy in late summer on honey mesquite is related to a less favorable growth environment and initiation of senescence (Meyer et al. 1971).

Leaf removal up to 50% prior to herbicide treatment did not appear to reduce herbicide effectiveness on greenhouse-grown or natural field-grown honey mesquite trees provided treatments were made under a favorable time of year (June) and environment. In some situations leaf removal increased herbicide activity possibly due to improved canopy penetration and spray retention on leaf and stem surfaces. After 50% hand defoliation, enough leaf area apparently exists to intercept the spray and absorb enough herbicide for lethal activity compared to no defoliation. Bovey et al. (1988b) found that the main mode of clopyralid uptake by honey mesquite was via leaves since no plants were killed and extremely low clopyralid concentrations were found in basal stem phloem after treating hand defoliated plants or the soil under foliated plants. Data in this report indicate that the grower should obtain good control of honey mesquite even if some natural defoliation has occurred because of insect or weather damage or removal by grazing animals provided treatments are applied under favorable growing conditions during spring and summer months.

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