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Suppression of resprouting in pruned mesquite (*Prosopis glandulosa* var *glandulosa*) saplings with chemical or physical barrier treatments

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Abstract

Chemical and light barrier methods were evaluated over a 2 year period as to their effects on suppression of resprouting in pruned mesquite saplings. Trees were thinned and pruned leaving one clear stem. A randomized complete block design with five blocks was used in both 1995 and 1996. From the 19 treatments examined in 1995, 10 treatments were selected for further study in 1996. The chemical treatments were applied to the pruned site with a paint brush in 1995 and a spray bottle in 1996. After each growing season the resprouts were harvested and weighed. The greatest mean reduction in resprouts was obtained with the 20% triclopyr concentration in diesel fuel in 1995 and 20% triclopyr in vegetable oil in 1996. When averaged over both years, the non-chemical, light-barrier, tree-wrap, had the lowest resprout along the main stem. However, this treatment did not control the profuse sprouting from stumps from multiple ground level stems of the same tree. The highest concentrations of triclopyr had the lowest tree growth rates. Additional long term experiments are needed, particularly with triclopyr, to find the techniques for resprout reduction that will not reduce tree growth rates. © 1998 Elsevier Science B.V. All rights reserved.

1. Introduction

Pruning mesquite (*Prosopis* sp.) is important in improving its lumber quality and ornamental context use due to its multi-stemmed nature (Fisher et al., 1959; Larson and Sodjoudee, 1982). Development of lumber quality trees from *Prosopis* is important because the volumetric shrinkage of *Prosopis* is only 4–5%, while its radial and tangential shrinkage are equal to each other (Tortorelli, 1956; Weldon, 1986). In comparison, oak (*Quercus* sp.), walnut (*Juglans nigra*), and cherry (*Prunus serotina*) have volumetric shrinkage values of 14.7%, 13.9%, and 11.5% respectively. The tangential shrinkage: radial shrinkage ratio for oak, walnut, and cherry is 2.1, 1.4, and 1.9 respectively (Panshin and de Zeeuw, 1980). The attractive natural color, interesting grain, and texture of *Prosopis* can equal the finest hardwoods (Weldon, 1986). It is important to place priority on development of lumber products from *Prosopis* since the value of mesquite for lumber ($ 1214 metric ton^{-1} for *Prosopis* lumber (@ $ 850 m^{-3} and specific gravity of 0.7) is far greater than its value of $ 360 metric ton^{-1} (J. Lawson, 1996 pers. comm.) for mesquite barbecue products. Even if only short (1.5 m), small diameter (20–40 cm)

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logs can be obtained, small diameter log processing techniques (Dunmire et al., 1972; Rosen et al., 1980; Reynolds and Gatchell, 1982) are available to process these logs into lumber suitable for furniture. As non-irrigated managed mesquite stands have averaged 1.2 cm in basal diameter growth per year over 9 years (Patch and Felker, 1997), the volume growth is great enough to be economically viable.

Mesquite readily produces root sprouts, stump sprouts, and stem sprouts when apical dominance is broken (Fisher et al., 1946; Meyer et al., 1971). Suppression of this resprouting should result in clear wood and a higher quality and more valuable stem.

Reducing resprouts in fruit trees (Boswell et al., 1976, 1977; Brana and Jackson, 1982), nursery stock (Bir and Ranney, 1993), and utility pruned hardwoods (Kimball, 1990; Tamsberg, 1990; Arron, 1991) has been described. The only report of chemical applications to control resprouts in mesquite (Meyer and Felker, 1990) demonstrated a significant (50%) reduction in resprouts with a 1% naphthalene acetic acid (NAA) solution. However, many resprouts still occurred in the best treatment. We inadvertently discovered the mesquite herbicide, triclopyr, killed basal resprouts of large pruned trees without damaging mature trees. Thus this study evaluated additional mesquite herbicides for their efficacy in suppression of resprouts in thinned and pruned mesquite saplings.

Table 1
Formulations and costs of treatments in 1995 to control resprouting of *Prosopis glandulosa* in Ricardo, Texas

Treatment	Conc. active ingred. (%)	Conc. of chemical in mix (%/solvent)	Cost
1. Control	N/A	N/A	N/A
2. NAA		1 /water & isopropanol	
3. Tre-hold	1.15	RTU[a]	$ 2.00/tree
4. Tre-hold	1.15	75 /water	$ 1.50/tree
5. Diesel	N/A	N/A	$ 0.01/tree
6. Tree-wrap	N/A	N/A	$ 0.92/tree
7. Picloram	24.4	5 /water	$ 0.03/tree
8. Picloram	24.4	10 /water	$ 0.05/tree
9. Triclopyr	61.6	20 /water	$ 0.11/tree
10. Triclopyr	61.6	20 /diesel	$ 0.11/tree
11. Clopyralid	40.9	2.5 /water	$ 0.04/tree
12. Paclobutrazol	21.8	7.9 /water	
13. Picloram	24.4	0.5 /water	<$ 0.01/tree
14. Picloram	24.4	1 /water	$ 0.01/tree
15. Triclopyr	61.6	2 /water	$ 0.01/tree
16. Triclopyr	61.6	2 /diesel	$ 0.02/tree
17. Clopyralid	40.9	.25 /water	<$ 0.01/tree
18. Clopyralid	40.9	.25 /diesel	$ 0.01/tree
19. Clopyralid	40.9	2.5% /diesel	$ 0.05/tree

[a]RTU (ready to use).

2. Materials and methods

The study area was located 15 km south of Texas A & M University, Kingsville in a native stand of *Prosopis glandulosa* var *glandulosa*. Treatments included herbicides known to kill mesquite (Meyer and Bovey, 1979; Mayeux and Crane, 1985; Bovey et al., 1989; Jacoby et al., 1990, 1991), growth regulators known to inhibit resprouts (Brana and Jackson, 1982; Wood, 1984; Bir and Ranney, 1993), and a commercially available physical light barrier to prevent resprouts (tree-wrap) (Table 1).

An initial experiment conducted in 1995, screened 19 treatments for their effectiveness in reducing resprouts in mesquite. A second experiment was conducted in 1996 that focused on the most promising treatments from 1995. A randomized complete block design with a single tree replicate per block and 5 blocks was used in both years. In 1995, there were 19 treatments per block and 5 blocks, while in 1996 there were 10 treatments with 5 blocks. In 1995 no growth measurements were taken while in 1996 growth in basal diameter was measured. Growth in biomass was estimated from basal diameter measurements with previously described regression equations (Felker et al., 1989) for *P. alba* trees with a 7.7 cm mean diameter and a 2.1–16.4 cm diameter range. The equation is:

$$\log \text{fresh wt (kg)} = 2.7027 \times \log \text{diameter (cm)} - 1.1085$$

To increase the precision of the measurements, the trees were spray-painted at the point on the trunk where the diameter was taken. The 95 trees in 1995 had a mean (±95% CI) of 2.81±0.32 stems tree^{-1}. The number of multiple stems tree^{-1} had the following distribution: 22% had one stem tree^{-1}, 30% had two stems tree^{-1}, 17% had 3 stems tree^{-1}, 13% had 4 stems tree^{-1}, 13% had 5 stems tree^{-1}, 4% had 6 stems tree^{-1}, and 1% had 8 stems tree^{-1}. As 78% of the trees had more than one stem and as each tree was pruned to

1 stem^{-1} tree, there was considerable variation in the number of stumps tree^{-1}, with some trees having no stumps. Due to the varying number of stumps tree^{-1}, the mean total resprouts tree^{-1} may not equal the mean of resprouts stem^{-1} + mean of resprouts stump^{-1}. The diameter of the trees ranged from 10 to 15 cm and their height was about 4 m.

The treatment trees in the plot were thinned to 2 m in all directions on 4–5 March 1995. During 18–19 March the trees were pruned and treatments were applied. Before pruning, the number of stems and branches removed per tree was measured. Shoots that arose from the ground level were designated stems. Branches were shoots arising from the main stem. The treatments were applied immediately as the branches and multiple stems were removed. The active ingredients, formulations and costs of treatment chemicals used in 1995 are indicated in Table 1. In 1995, the chemical solutions were applied directly to the wound sites with a paintbrush, while in 1996 they were applied with a 1 l plastic sprayer. The volume of the chemical used for the treatments was determined from the difference in initial and final volume. The fresh weight of tree stem resprouts, trees stump(s) resprouts, and total tree resprouts was measured in the field with a portable balance in September 1995 and in September 1996.

Due to the high variability encountered in the quantity of resprouts, three complementary statistical approaches were employed i.e. Analyses of Variance (and means separation if the ANOVA was significant), 95% confidence intervals and LS means tests. The 95% confidence intervals provide an estimate of the variability and also allow pair wise comparisons for significant differences. For the 1996 growth data, an LS means test was used to compare all possible pairs for significant differences due to the high variability in some treatments that resulted in a non-significant ANOVA. To determine if there was a correlation between the biomass removed before application and the fresh weight of the resprouts, Pearson correlation coefficients were calculated.

3. Results and discussion

In 1995 there was about an 80-fold difference observed in means of total resprouts between the greatest and least resprout reduction over the 19 treatments (Table 2). The high variability within treatments, coupled with only five replicates/treatment, resulted in few significant treatment differences. The triclopyr treatment at a concentration of 20% in diesel fuel was the most successful treatment for stem, stump and total resprout reduction, but it was only significantly greater than a few of the other treatments (Table 2). The tree-wrap (light barrier) was second in controlling resprouts along the stem, but it was not significantly different from the other treatments. As the tree-wrap did not cover the base of the tree there was considerable resprouting at that point. There were no significant differences for the stem resprout category.

In the stump resprout category the number one treatment, i.e. the 20% triclopyr in diesel fuel treatment, had significantly greater (based on 95% confidence intervals – the ANOVA was not significant) resprout reduction than 2.5% clopyralid in diesel fuel, 1% picloram in water, and 0.25% clopyralid in water. The top five ranked treatments had significantly greater resprout reduction than the number 10 ranked 0.25% clopyralid in water. The tre-hold (commercial NAA) at a 75% concentration in water ranked third for all treatments, but was not significantly different from any of the other treatments.

For the 1995 data, the Pearson Correlation Coefficients for the number of stems cut and the fresh weight of resprouts was non-significant (r=0.08, p=0.45). The correlations of total number of stems plus branches cut with the total resprout fresh weight was also non-significant (r=0.02, p=0.84).

A second experiment was conducted the following year with more concentrations and formulations of the most promising compounds (Table 3). To reduce the chemical costs, an intermediate 10% triclopyr concentration was examined. In addition, the carrier vegetable oil was examined since it was less toxic to human beings and less environmentally damaging than diesel fuel. The only treatments that significantly decreased resprout reduction on the main stem below the control were tree-wrap, 10% triclopyr in diesel, 20% triclopyr in diesel and 20% triclopyr in vegetable oil (Table 3). None of the treatments had significantly less resprout reduction from the stump than the control (830 g), although the 2% triclopyr in diesel was 160 g and the 20% triclopyr in vegetable oil was 120 g.

Table 2
Mean fresh weight (g) and 95% confidence interval (CI) for *Prosopis glandulosa* resprouts from stems, stumps, and entire tree in Ricardo, Texas, September, 1995

Treatments[1]	Total fresh weight (n=5) (g)	Stem fresh weight (n=5) (g)	Stump fresh weight (g)	n^2
Triclopyr 20% D	37±81a	30±83	9±30	4
Picloram 5% W	291±351ab	171±354	300±2033	2
Tre-hold 75% W	318±303ab	124±77	242±424	4
Triclopyr 2% D	348±343ab	150±276	247±493	4
NAA 1% W/I	436±455ab	238±459	247±506	4
Clopyralid 2.5% W	511±567ab	377±532	134±298	5
Paclobutrazol	600±756ab	214±368	643±2043	3
Clopyralid 2.5% D	788±566abc	338±333	2743±1679	3
Triclopyr 20% W	824±840abc	334±655	613±1193	4
Triclopyr 2% W	875±665abc	227±473	810±988	4
Picloram 0.5% W	896±1301abc	224±281	865±1379	4
Diesel fuel	980±1374abc	398±569	728±1099	4
Tree-wrap	1112±939abc	98±272	1283±1246	4
Control	1170±1684abc	340±556	1383±2321	3
Picloram 10% W	1327±1272abc	206±1272	1121±1291	5
Tre-hold 100%	2116±2280bcd	750±1191	1366±1425	5
Picloram 1% W	2148±1276bcd	534±568	1614±991	5
Clopyralid 0.25% W	2550±3180cd	904±1430	2743±1853	3
Clopyralid 0.25% D	3028±4228d	142±140	2886±4301	5

[1] D, diesel fuel; W, water; I, isopropanol.
[2] n, varies in the stump category depending on the number of multi-stemmed trees within each treatment.
Means followed by the same letter are not significant as judged by Duncan's multiple range test.

However, it is possible that with a greater number of replications, a significant effect could have been achieved.

Due to different effects of the chemicals on resprouts from the stump and stem, the statistical differences for total resprouts were different from the stem and stump (Table 3). Both the 20% triclopyr in diesel and the 20% triclopyr in vegetable oil were significantly lower than the control. At the lower concentrations of triclopyr i.e. 2% and 10% the diesel carrier was more effective than the vegetable oil. In contrast at the highest concentration of triclopyr (20%), the vegetable oil carrier had less resprouts than the diesel carrier.

Table 3
Effect of tree hold, and triclopyr in vegetable oil and diesel on resprout reduction and growth in *Prosopis glandulosa* in 1996

	Total resprout (g) Mean±95%CI	Stem resprout (g) Mean±95%CI	Stump resprout (g) Mean±95%CI
Triclopyr 20% V	200±330 a	81±90 a	120±330 a
Triclopyr 20% D	390±720 ab	80±120 a	310±720 a
Triclopyr 2% D	460±310 abc	290±370 ab	160±310 a
Triclopyr 10% D	600±460 abc	180±210 a	420±460 a
Triclopyr 10% V	760±380 abcd	270±250 ab	490±380 a
Triclopyr 2% V	840±690 abcd	340±620 ab	500±690 a
Tree-wrap	1380±650 abcd	70±160 a	1310±650 b
Control	1470±120 cde	640±530 b	830±1200 ab
Tre-hold, whole tree	1760±1130 de	430±540 ab	1330±1130 b
Tre-hold, wound only	1920±780 e	500±200 ab	1420±780 b

Means having at least one common letter (a, b, c, d or e) are not significantly different (Duncan's multiple range test) (n=5).
D, diesel as a carrier; V, vegetable as a oil carrier.

Table 4
Weight and diameter increase of mesquite trees whose pruned surfaces were treated with chemicals or light barriers over March to September 1996 growing season

	Weight increase (kg) Mean±95%CI	Diameter increase (cm) Mean±95%CI
Tree-wrap	4.14±3.73	0.46±0.24
Triclopyr 2% D	3.95±3.95	0.36±0.29
Triclopyr 2% V	3.81±3.17	0.34±0.19
Tre-hold, wound only	3.68±3.96	0.38±0.28
Triclopyr 10% V	2.49±1.08	0.10±0.18
Triclopyr 10% D	2.33±1.77	0.30±0.25
Control	1.94±0.75	0.24±0.07
Tre-hold,whole tree	1.92±1.38	0.20±0.09
Triclopyr 20% V	1.37±1.82	0.14±0.19
Triclopyr 20% D	1.05±0.95	0.18±0.18

D, diesel as a carrier; V, vegetable oil as a carrier.

The ANOVA did not show significant differences for weight or diameter growth Table 4 following these treatments. Due to the high variability in some of the treatments we compared individual treatment pairs for significance using an LS means test. The LS means contrasts found significant differences in diameter growth (p<0.05) between control vs. tree-wrap; between tree-wrap vs. tre-hold, triclopyr 20% D, triclopyr 20% V and the control; between triclopyr 10% V vs. triclopyr 20% D, and triclopyr 20% V; between tre-hold vs. triclopyr 20% V; and triclopyr 20% V vs. tree-wrap and triclopyr 2% D. For weight, the LS means contrasts found a significant difference (p<0.05) between tree-wrap vs. triclopyr 20% D; tree-wrap vs. triclopyr 20% V; between triclopyr 2% D vs. triclopyr 20% D; triclopyr 20% D vs. triclopyr 2% V, and tre-hold vs. triclopyr 20% D.

Except for one tree that died in both the 20% triclopyr in diesel and 20% triclopyr in vegetable oil treatment, no yellowing of foliage, or stem kill were noted in any of the treatments. None of the trees from the 1995 treatments died.

A comparison of the results from 1995 and 1996 reveals that the resprouts from the control were similar in both years. In both years, the treatment with the best overall reduction of resprouts contained 20% triclopyr. In 1995, the best 20% triclopyr was in diesel, while in 1996 the best treatment was the 20% triclopyr in vegetable oil. Even in 1996, the diesel and vegetable oil formulations were very similar. In 1995, the resprout reduction on the main stem was much lower from the 20% triclopyr in diesel than in 1996. In both years the tree-wrap had excellent control of resprouts along the main stem but no effect of resprouts from the stump. The commercial formulation of NAA i.e. tre-hold, was much less effective in 1996 than in 1995. While the tre-hold had about 35% of the resprout production of the control in 1995, in 1996 both applications of tre-hold had greater resprout production than the control. As the fresh weight of resprouts found on the stumps was in most cases 2–20 times greater than the fresh weight of resprouts along the stem, the stump resprouts had a stronger influence on the total than did the stem resprouts (Table 2).

Since clopyralid was more effective than triclopyr in causing mortality to *Prosopis* (Mayeux and Crane, 1985) we found it surprising that clopyralid was not more effective than triclopyr in resprout suppression. If these high concentrations of triclopyr in diesel were applied at one height completely around the tree, complete mortality would result (McGinty and Ueckert, 1995). While no tree yellowed or lost leaves in 1995, two trees in the highest triclopyr concentration died in 1996. This high concentration of triclopyr also had the lowest growth rate and a growth rate that was significantly lower than the treatments with no or low chemical concentrations. Thus more experiments need to be conducted to measure the influence of these treatments on the growth rate of the trees. Since the chemicals were applied with a hand held sprayer in 1996, it is possible that the spray extended beyond the pruned surface and caused damage to the trees. If tree growth is indeed slowed, it will be necessary to examine the tradeoffs between enhanced lumber grades from lack of resprouts against lowered growth for the season the chemical was applied.

The cost (Table 1), accessibility of the chemical, and level of toxicity should be considered along with success rate before making management recommendations. The experiments in the second year to find an intermediate concentration of triclopyr (i.e. 10%) that would be effective was not successful. Although, the 20% rates of triclopyr gave the greatest overall reduction, there was considerable variation among all the three concentrations. At least at the highest concentration, the vegetable oil formulation was as effective as the diesel fuel formulation. While vegetable oil is more oil environmentally friendly than diesel fuel, vegetable oil is more costly i.e. $ 1.25/l vs. $ 0.25 for diesel. However, given the much greater cost of triclopyr i.e. $ 20/l, these differences are not so important. Clopyralid is not as promising as triclopyr; since picloram is a restricted chemical while triclopyr is not, since picloram had some of the highest variabilities of all the treatments and, since picloram offers little price advantage over triclopyr. Given the low performance of the NAA based formulations, we suggest they also be abandoned in favor of triclopyr based formulations.

The tree-wrap was one of the most costly treatments, but it ranked second in 1995 and first in 1996 in the reduction of mean stem resprouts and it has no toxic effects. Possibly other less costly light barrier techniques could be developed. As the effectiveness of herbicide treatments designed to kill *Prosopis* is strongly affected by the season of the year, it would be useful to examine various rates and carriers of the most effective chemicals during various seasons.

4. Conclusions

The 20% triclopyr treatments had the greatest resprout reduction in both the years. In 1996 the greatest resprout reduction occurred in the 20% formulation in more environmentally friendly vegetable oil. The tree-wrap treatments had excellent resprout reduction along the main stem in both years, but as the tree-wrap could not be placed over the stumps, it had no effect on stump resprouts. A 20% triclopyr in vegetable oil was the most promising treatment for control of stem and stump resprouts on pruned mesquite trees. Given the lower growth rates of the treatments containing triclopyr and the mortality of trees only in these treatments, more experiments are required with 20% triclopyr concentrations to ensure that this treatment will not cause mortality or decreased long term growth rates.

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