CHEMICAL RELEASE OF POLE-SIZED TREES IN A CENTRAL HARDWOOD CLEARCUT

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Abstract: Our study evaluated the effectiveness of tree injection and full basal bark treatments using three herbicide formulations at reduced or standard practice rates to release crop trees in an overstocked pole-sized Central Hardwood stand. Herbicides tested included glyphosate (Accord), dicamba only (Banvel CST), and dicamba+2,4-D (Banvel 520). The study was conducted in a mixed hardwood stand in southern Illinois that regenerated following a clearcut harvest 18 years earlier. A highly significant interaction occurred among the six herbicide treatments and the method of application. Full basal bark treatment with any of the three herbicide formulations at either rate produced only light (8 to 25%) crown reduction at 45, 90, and 360 days after treatment (DAT). Tree injection with the high and low rate of glyphosate (4 and 8% ai), the ready-to-use dicamba (10.6% ai), and the registered rates of dicamba+2,4-D (1.7 and 2.4% ai, respectively) caused severe (64 to 78%) crown reduction on the treated trees and shrubs. The shrubs as a group were the most susceptible to the herbicide treatments, while sugar maple was the most herbicide-tolerant tree species. The elms, ashes, low-value hardwoods, and high-value hardwood groups were intermediate in response. Non-treated (crop) trees showed no visible crown reductions or reduced diameter growth following chemical release. We conclude tree injection application of glyphosate or dicamba can be an acceptable method for chemical release of crop trees in mixed hardwood stands.

INTRODUCTION

Forest inventories for the Central Hardwoods indicate that the amount of young hardwood growing stock has continued to increase following planting of abandoned agricultural lands and sapling regeneration in clearcuts. Many of the resulting stands are now overstocked with young pole-sized trees of little or no commercial value. Inexpensive, environmentally acceptable methods need to be developed if landowners are going to manage these stands to meet their objectives for wildlife habitat improvement, recreational opportunities, and timber production (Miller and Glover 1991).

Chemical release is a relatively inexpensive method of removing unwanted shrubs and trees when methods are identified that prevent ground water contamination, pose little risk to non-target organisms, and are not labor intensive. In the past, hardwood stands were thinned mechanically by cutting or girdling or chemically released using tree injection and, to a lesser extent, full basal bark treatments. Limited information exists on the effectiveness of several broad-spectrum herbicides developed for agricultural use on hardwood shrubs and trees. This includes using

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both tree injection and basal bark treatments (Griswold et al. 1989). Ideally, these broad-spectrum herbicides should exhibit low toxicity to non-target organisms and would be quickly adsorbed by soil, thus preventing ground water contamination.

Another advantage of chemical release of hardwood stands over mechanical methods would be less drastic changes in stand density as trees slowly die out. The partial crowns of treated trees would provide side shade to the non-target trees reducing chances of epicormic sprouting. In addition, upright decaying stems could provide improved wildlife habitat over a longer time interval.

Label recommendations for chemical release are usually established as the maximum amounts needed to achieve a nearly complete kill of all treated trees and shrubs within a single growing season while still protecting the environment, the user, and the chemical company. Substantial differences in tolerance can exist among different species depending on the herbicide, its formulation, and method of application (Gjerstad and Nelson 1986; Norris 1981). The effectiveness of reducing rates by one-third to one-half are usually not given on the herbicide label. Potentially reduced rates could cause partial crown reduction of treated trees leading to reduced growth and subsequent entrance to a less competitive canopy position.

This study was designed to evaluate the effectiveness of tree injection and basal bark treatments with three herbicide formulations applied at standard practice and reduced rates to chemically thin an 18-year-old mixed hardwood stand. Secondly, we wanted to determine if differences in tolerance exist among different tree species to these herbicides and/or their methods of application. Finally, we wanted to learn if these herbicides affected growth of the adjacent untreated hardwoods.

METHODS

We initiated the study in 1990 on a mixed hardwood stand on a small watershed at the Dixon Springs Agricultural Research Center in southern Illinois. The stand originated following a clearcut harvest 18 years earlier. Stand composition was approximately 35% sugar maple, 10% red bud, 9% slippery elm, 6% sassafras, 6% winged elm, 5% white ash, 4% hickory, 4% black cherry, 4% devil's walking stick, 3% northern red oak, 3% mulberry, 3% yellow poplar, 3% white oak, and 5% other minor trees and shrubs. Soils were primarily Grantsburg silt loams (fine-silty, mixed, mesic Typic Fradiudalfs) with slopes between 3 and 7%, southerly aspect, a pHw of 5.7, and an organic matter content of 5.1%.

In 1989 the stand had been marked to retain approximately 400 non-treatment trees per hectare. These included primarily high-value timber and mast-producing hardwoods (white oak, northern red oak, white ash, hickory, black cherry and tulip poplar). For this study we divided the watershed into forty-eight 8- x 16-m rectangular plots containing 2.8 ± 1.9 ($n = 48$) non-treatment trees each. Twenty-four plots outside the riparian zone were randomly assigned for treatment by the tree injection and 24 additional plots for full basal bark treatment. Plots contained an average of 24.5 ± 13.9 ($n = 48$) treated trees or shrubs and 6.2 ± 1.5 ($n = 48$) different species.

All chemical treatments were applied during the last week of May 1991. For tree injection (hack-and-squirt), we made a series of 4.5-cm-long incisions or frills 3 cm apart into the sapwood conductive tissues with a hand ax approximately 1 to 1.5 m above the ground. Approximately 1 ml of test solution was immediately applied to each incision using a squirt bottle. We tested glyphosate (Accord) at below recommended rate by diluting it with water to give a 10% or 20% (ai) solution. We applied ready-to-use dicamba (Banvel CST) at the recommended rate using an 11.0% solution. We also tested a dicamba+2,4-D mix (Banvel 520) diluted with oil (Androc) containing either 1.3% or 3.9 % dicamba and 3.4% or 10.2% isooctyl ester of 2,4-D, respectively. Trees in the control plots were treated with 1 ml of water per incision. Four replications of each herbicide treatment were randomly assigned to the 24 plots marked for herbicide application by tree injection.

For full basal bark treatments, we wetted the lower 20 to 25 cm of the stem to drip-point using a backpack sprayer equipped with a cone tip. We applied glyphosate at reduced rates as either a 4% or 8% (ai) solution in water without the addition of oil or a surfactant. Dicamba only was applied directly as the ready-to-use aqueous formulation containing 10.6 % ai dicamba. The dicamba+2,4-D mix was applied as a solution containing 0.7% or 1.3% ai dicamba and 1.7% or 3.4% ai 2,4-D diluted with oil. Trees in the control plots were sprayed with water only. Four replications of each herbicide treatment were randomly assigned to the 24 plots marked for basal bark treatment.

We visually estimated average plot crown reduction to within 5% for each shrub or tree species 45, 90, and 360 days after treatment (DAT). A percentage crown reduction of 0% indicated no visible dying leaves or defoliated branches while 100% indicated complete defoliation of the crown with no basal sprouts. To determine treatment responses by species, we divided the treated shrubs and trees into the following classes: maples (essentially all sugar maple), ash (mostly white ash), elms (nearly equal proportions of slippery and winged elms), mixed shrubs (redbud, sassafras, persimmon, sumac, and devil's walking stick), low-value hardwoods (persimmon, mulberry, and various hickories), and the high-value hardwoods (northern red oak, white oak, black cherry, black walnut, and yellow poplar).

The species and diameter at breast height (dbh) of each crop tree were determined in early March 1991 and again in early November 1992 (after two growing seasons). Visual estimations of crown reduction were made also on the non-treated trees 45, 90, and 360 days after application of herbicides to the adjacent hardwoods.

Percent crown reduction was calculated for each plot and subjected to a two-way analysis of variance for a completely random design with factorial arrangement of the five herbicide formulations and water control, the two methods of application, and their interaction (SAS Institute Inc. 1988). We used Fisher's protected LSD (5% t-test value) to determine where differences existed among treatment means for main effects or for their interactions. Terminology for degree of crown reduction (very light to severe) is according to Miller and Glover (1991). We subjected the 2-year dbh growth of non-treated trees to the same two-way ANOVA after excluding the small number of black cherry and tulip poplar crop trees with growth rates nearly double that of the other crop trees.

RESULTS AND DISCUSSION

We found a highly significant interaction among the six herbicide treatments and the method of application for the average percent crown reduction of treated mixed hardwoods (Table 1). This interaction was present at 45, 90, and 360 DAT. Basal bark treatment with glyphosate at both rates, dicamba+2,4-D at both rates, or dicamba ready-to-use resulted in light crown reduction of treated trees. Tree injection was a more effective method for applying glyphosate, dicamba, or dicamba+2,4-D than was full basal bark treatment. The standard practice rates of dicamba and dicamba+2,4-D plus both rates of glyphosate when injected resulted in severe crown reduction of the treated trees. In contrast, the reduced rate of dicamba+2,4-D resulted in light crown reduction compared to the severe crown reduction from the lowest rate of glyphosate. We suspect that severe crown reduction will cause many of these codominant trees to die or become part of the intermediate or suppressed canopy class in the treated plots.

With the full basal bark treatment, only one herbicide (dicamba+2,4-D) at the standard practice rates showed increasing amounts of crown reduction during the second growing season (Table 1). These results suggest that this oil-based herbicide once absorbed into the bark can remain active for more than one growing season. A similar, but less pronounced, pattern existed when the oil-based herbicide was injected. These results suggest expanded studies need to be done comparing injection vs. basal application of other highly effective basally applied herbicides such as triclopyr and picloram with and without 2,4-D. The test herbicides in this study were chosen because of their effectiveness when injected and low risks for environmental damage.

According to Miller and Glover (1991), herbicide treatments resulting in more than a 70% control of the treated trees with acceptable crop tree tolerance should be considered successful. Miller (1990) found that chemically treated hardwoods with over 80% crown reduction eventually died, while trees with less than 40% crown reduction usually recovered. Miller, however, did not indicate if recovered trees now occupied a lower canopy class resulting in less

Table 1.--Crown reduction (%) of treated hardwoods 45, 90, and 360 days after treatment (DAT) with six herbicide formulations using two methods of application.

Method and Herbicide	Conc. Active Ingredient	Percentage Crown Reduction Treated Trees[1] 45 DAT	90 DAT	360 DAT
	%	--%--	--%--	--%--
TREE INJECTION:				
Glyphosate	20	74	72	68
Glyphosate	10	63	64	69
Dicamba+2,4-D	3.9+10.2	64	69	74
Dicamba+2,4-D	1.3+ 3.7	23	25	27
Dicamba only	11.0	74	74	78
Water	----	1	1	2
BARK BASAL TREATMENT:				
Glyphosate	8	19	19	18
Glyphosate	4	11	10	5
Dicamba+2,4-D	1.3+3. 4	14	18	31
Dicamba+2,4-D	0.7+1.7	1	1	1
Dicamba only	11.0	25	28	23
Water	----	0	0	0
5% t-test value		19	18	21

[1]Values deviate from those previously reported by Kai et al. (1992) because of method of calculation and correction of values for basal bark treatment with dicamba+2,4-D.

competition to the released trees. Thus, nearly all the herbicide treatments using the injection method would have qualified as being successful assuming no damage to the non-treated trees. Percent crown reduction averaged across all species, however, does not indicate if these treatments resulted in severe to very severe crown reduction of some hardwood species and light to moderate crown reduction for less susceptible species or groups of species.

When percentage crown reductions were analyzed by species groups, we found that the maples were least susceptible to most of the herbicide treatments (Table 2). At the standard practice rate for glyphosate, dicamba, or dicamba+2,4-D, the injection method only resulted in moderate crown reductions on the sugar maples. Basal bark treatment resulted in very light to light crown reductions from which most trees will probably quickly recover. This confirms earlier observations on the high tolerance of pole-sized sugar maples to herbicides (Brinkman 1970, Newton and Knight 1981).

As a group, the shrubs were more susceptible to the tested herbicides than most of the other hardwood species (Table 2). Injections using the reduced rates of glyphosate or dicamba+2,4-D resulted in severe to very severe crown reduction of most shrubs. Although basal bark treatments with reduced rates were ineffective for most of the species groups, they did result in moderate crown reductions for the treated shrubs. Typically, most shrubs have thin bark that may account for their increased susceptibility to these broad spectrum herbicides.

Only minor differences were found in susceptibility among the ashes, elms, and other tree species to the tested herbicide combinations (Table 2). In general, these hardwoods had severe to very severe crown reductions following injections of glyphosate, dicamba, or dicamba+2,4-D. Full basal bark treatments with standard practice rates for glyphosate and dicamba+2,4-D tended to produce light to moderate crown reduction. The response to basal bark application of ready-to-use dicamba gave mixed results. The number of treated trees within any species group never

Table 2.--Crown reduction (%) for each species class 360 days after treatment (DAT) with six herbicide formulations using two methods of application. Changes of more than 10% from percentages after the first growing season are marked with a + or -, respectively[1].

Method and Herbicide	Conc. Active Ingredient	Maple	Ash	Elms	Hardwoods Mixed shrubs	Hardwoods Lesser value	Hardwoods High value
	%	--%--	--%--	--%--	--%--	--%--	--%--
TREE INJECTION:							
Glyphosate	20	41 -	38	100	96	100	100
Glyphosate	10	48	82	69 +	100 +	81 +	87
Dicamba+2,4-D	3.9+10.2	45 +	92 +	100	91	50 +	89 +
Dicamba+2,4-D	1.3+ 3.7	4	0	29	67	2	0
Dicamba only	11.0	38	100	100	100	100 +	77 +
Water	----	0	2	0	0	0	0
BARK BASAL TREATMENT:							
Glyphosate	8	0	17	35	29	26	0
Glyphosate	4	1	0	0	13 -	0	4
Dicamba+2,4-D	1.3+3.4	8	25 +	27 +	50 +	25	33 +
Dicamba+2,4-D	0.7+1.7	0	0	0	0	0	9
Dicamba only	11.0	7	100	15	65	40	19
Water	----	0	0	0	0	0	0
5% t-test value:		19	37	33	39	39	36
Number plots included:		46	28	43	42	39	41

[1]Values for 45 and 90 DAT can be found in Kai (1993).

met the criteria of 30 to 50 test plants as recommended by Miller and Glover (1991) for herbicide efficacy determinations; thus, these observations will require further testing.

Visual inspection of the crop trees did not show any discolored or deformed foliage or deformed shoots. Similarly, we found no differences in stem diameter growth of the crop trees during the first two growing seasons after treatment (Table 3). This suggests that the non-treated trees had absorbed little if any of the herbicides through root grafts or from the soil. In addition, it also indicates the crop trees have not responded to any of the release treatments.

SUMMARY

Chemical release using tree injections of glyphosate, dicamba, or dicamba+2,4-D effectively removed most unwanted hardwoods, except sugar maple, in a mixed hardwood stand. Reduced rates of glyphosate were nearly as effective as the standard practice rates for dicamba-based herbicides. Reduced rates for dicamba+2,4-D were generally unsuccessful except on the thin-barked shrub species. For full basal bark application, ready-to-use dicamba was more effective than either glyphosate or dicamba+2,4-D solutions. Standard practice rates of dicamba+2,4-D in oil using either tree injection or full basal bark application consistently caused more crown reduction during the second growing seasons than during the first growing season. The non-treated or crop trees showed no visible crown reduction or reduced diameter growth in response to any of the herbicide treatments. In conclusion, tree injection application of dicamba or dicamba+2,4-D at standard practice rates or glyphosate at less than standard practice rates can be an acceptable alternative to release crop trees in mixed hardwood stands unless stands are dominated by sugar maple.

Table 3.--Average diameter growth of crop trees two years after chemical release using factorial combinations of six herbicide formulations and two methods of application[1].

Release treatment		Method of Application	
Herbicide	Rate	Tree Injection	Full Basal Bark
		--cm--	--cm--
Glyphosate	High	0.29	0.34
Glyphosate	Low	0.43	0.26
Dicamba+2,4-D	High	0.36	0.31
Dicamba+2,4-D	Low	0.33	0.32
Dicamba only	RTU	0.25	0.34
Water	----	0.37	0.28
5% t-test value		0.16	

[1]Crop trees in order of relative density include white oak, white ash, northern red oak, green ash, sugar maple, and black walnut.

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