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Injection Treatments for Killing Bottom-Land Hardwoods[1]

FRED A. PEEVY[2]

Abstract. Injection of undiluted dimethylamine salt of (2,4-dichlorophenoxy)acetic acid (2,4-D) containing 479 g/L killed several species of bottom-land hardwoods when applied in 1 or 2-ml dosages in injections spaced from edge-to-edge to 23 cm apart. Most hardwoods were easier to kill in June than in September or December. For greatest economy, treatments should be varied by species and seasons. A 4:1 mixture of triisopropanolamine salts of 2,4-D and 4-amino-3,5,6-trichloropicolinic acid (picloram) containing 305 g/L was effective on some species resistant to 2,4-D, including eastern persimmon *(Diospyros virginiana* L.), swamp privet *(Forestiera acuminata* (Michx.)Poir.), and bitter pecan *(Carya* × *lecontei* Little).

INTRODUCTION

INJECTION with herbicides is a common method of removing undesirable hardwood trees from southern forests. By giving the land manager control over individual stems, it permits the weeding of stands that contain mixtures of desirable and undesirable trees. Where the weed trees are 10 cm or larger in diameter, injection is frequently more economical, as well as more selective, than alternative methods. It creates few environmental hazards.

In recent years, the development of injectors that accurately meter small amounts of fluid into each cut has permitted use of undiluted 2,4-D instead of oil or water mixtures of butoxy ethanol esters of 2,4-D and (2,4,5-trichlorophenoxy)acetic acid (2,4,5-T) (1, 4, 5). The method was first tested on upland sites, where it is now widely accepted because it improves the speed and certainly of death and reduces costs of material, transport, and labor. This paper reports research on treatments suitable to bottom-land forests, in which the species to be controlled are different from those in the uplands.

Because a 4:1 mixture of 2,4-D and picloram has proved effective on upland species resistant to 2,4-D (3), this formulation was included in the tests to treat bottom-land species that were thought to be resistant.

MATERIALS AND METHODS

Eight species were treated at 3 months during the year —June, September, and December. Preliminary tests to determine resistance of the species to the dimethylamine salt 2,4-D suggested the following grouping:

Easy to kill: American elm *(Ulmus americana* L.) and overcup oak *(Quercus lyrata* Walt.);

Moderately hard to kill: Bitter pecan, American hornbeam
(Carpinus caroliniana Walt.), and hawthorn
(Crataegus marshallii Eggelst.);

Resistant: Eastern persimmon, swamp privet, and green ash
(Fraxinus pennsylvanica Marsh.).

The trees were on a fine-textured clay soil that was poorly drained and frequently flooded during winter and early spring. They ranged from 15 to 41 cm in diameter.

Treatments were applied in September and December of 1967 and in June 1968. They were varied by seasons and species. Undiluted dimethylamine salt of 2,4-D (479 g/L) was applied with a metering injector in all combinations of two dosages and three spacings of incisions in three seasons on American elm and overcup oak, and in June and September on pecan, American hornbeam, and hawthorn.

The injector was of a standard commercial type. A cutting bit made an incision when the tool was jabbed into the tree bole, and the operator then actuated a valve that metered the desired quantity of herbicide from a reservoir in the tool handle. The herbicide flowed over the tool bit into contact with living cells in the lower tree trunk.

The 4:1 mixture of triisopropanolamine salts of 2,4-D and picloram (305 g/L) was applied to the moderately resistant species in December and to the resistant species in all three seasons (2). In most applications, 2,4-D was tested at dosages of 1 and 2 ml per incision. The chemical mixture was uniformly applied in 1-ml dosages because earlier work on upland hardwoods (1) had indicated that this amount might be sufficient if injections were appropriately spaced. Details of the dosages and incision spacings for the various species and seasons are given in the accompanying tables.

Each treatment was replicated three times and assigned to plots in a fully random design. A group of 10 trees of a species comprised a plot; intermingled trees of other species were not treated. Incisions were made within 10 cm of groundline with an injector bit 4.4 cm wide. Spacing of incisions was measured from edge to edge. In August 1969, about two growing seasons after the treatments were installed, crown injury was estimated visually to the nearest 5% for each tree, then averaged by plot and treatment. Kills averaging 91% or higher are generally regarded as satisfactory in timber stand improvement work, those of 85 to 90% marginal, and those under 85% unsatisfactory. Sprouting was negligible in all treatments and hence is not reported.

Differences in crown kill were evaluated at the 5% level of probability by Duncan's multiple range test.

RESULTS

In applications of 2,4-D to easy-to-kill species, the widest spacing of incisions (23 cm) and the 1-ml dosage proved effective on American elm at all seasons, and more intensive treatments did not significantly improve performance (Table 1). The same treatment was satisfac-

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[2]Plant Ecologist, 1102 Timber Management Research Project, Southern Forest Exp. Sta., US Dep. of Agr. Forest Service, Pineville, Louisiana 71360.

Table 1. Crown kill (%) of two easy-to-kill hardwood species injected with the dimethylamine salt of 2,4-D.[a]

Dosage	Spacings	American elm	Overcup oak
(ml)	(cm)	(%)	(%)
		June applications	
1	13	88 b	77 b
1	18	96 ab	69 b
1	23	94 ab	74 b
Average		93	73
2	13	97 a	94 a
2	18	100 a	90 a
2	23	97 a	75 b
Average		98	86
		September applications	
1	13	98 a	98 ab
1	18	100 a	93 b
1	23	97 a	93 b
Average		98	95
2	13	99 a	99 ab
2	18	99 a	100 a
2	23	94 a	96 ab
Average		97	98
		December applications	
1	8	100 a	100 a
1	13	100 a	100 a
1	18	100 a	96 b
Average		100	99
2	8	100 a	100 a
2	13	100 a	100 a
2	18	99 a	100 a
Average		100	100

[a]For a given species and month, values for dosages or spacings followed by the same letter do not differ significantly at the 0.05 level. A separate standard error was used for calculating the range for comparing averages for each month.

tory on overcup oak in September and December, but in June a 2-ml dosage at 18-cm spacings was required.

For moderately resistant species (pecan, American hornbeam, and hawthorn) an 8-cm spacing seemed desirable in June applications of 2,4-D (Table 2). At this spacing, the 1-ml dosage was as good as the 2-ml. At wider spacings, the only acceptable June treatment was a 2-ml dose on American hornbeam. Overall, September treatments were better than June applications on these species. The 1-ml dosage was uniformly satisfactory at 8-cm spacing but was marginal in some treatments at wider spacings. The 2-ml dosage was consistent at 8-cm spacings and was adequate at 13 cm on hawthorn and at 18 cm on American hornbeam.

Table 2. Crown kill (%) of moderately hard-to-kill hardwoods.[a]

Herbicide	Dosage	Spacings	Pecan	American hornbeam	Hawthorn
	(ml)	(cm)	(%)	(%)	(%)
				June applications	
2,4-D	1	8	87 a	94 ab	88 a
	1	13	69 a	77 bc	67 bc
	1	18	66 a	63 c	56 c
	Average		74	78	70
2,4-D	2	8	95 a	100 a	85 ab
	2	13	82 a	95 ab	77 ab
	2	18	77 a	86 b	65 bc
	Average		85	94	76
				September applications	
2,4-D	1	8	94 a	100 a	100 a
	1	13	78 a	91 b	90 bc
	1	18	92 a	82 c	66 d
	Average		88	91	85
2,4-D	2	8	95 a	96 ab	93 bc
	2	13	80 a	98 ab	99 ab
	2	18	93 a	95 ab	87 c
	Average		89	96	93
				December applications	
2,4-D	1	Edge-to-edge	68 b	86 a	100 a
	1	2.5	84 b	91 a	99 a
	1	8	29 b	53 c	98 a
	Average		60	77	99
2,4-D – picloram (4:1 mix)	1	Edge-to-edge	99 a	81 ab	100 a
	1	2.5	99 a	85 a	100 a
	1	8	98 a	65 b	100 a
	Average		99	77	100

[a]For a given species and month, values for dosages and spacings in June and September and for chemicals and spacings in December do not differ significantly at the 0.05 level when followed by the same letter. A separate standard error was used for calculating the range for comparing averages for each month.

In December, 2,4-D and the mixture of 2,4-D and picloram were tested only in 1-ml dosages and at spacings up to 8 cm (Table 2). The 2,4-D was effective on hawthorn at all spacings and marginal on American hornbeam in incisions made edge-to-edge or 2.5 cm apart. The chemical mixture was highly effective on pecan and hawthorn at all spacings but was unsatisfactory on American hornbeam.

On trees considered difficult to kill, both 2,4-D and the mixture were tested in all 3 months but only at the 1-ml dosage (Table 3). Spacings varied with season of application. In all seasons and with both chemicals, swamp privet was the most resistant species. In June 2,4-D was effective on green ash and eastern persimmon even at 13-cm spacings, the widest tested. It was unsatisfactory on swamp privet except at the 2.5-cm spacing. The 2,4-D and picloram combination was effective at 2.5 and 8 cm on swamp privet and at 13 cm on the other species.

Table 3. Crown kill (%) of hard-to-kill hardwoods with 1-ml doses of 2,4-D or the 4:1 mixture of 2,4-D and picloram.[a]

Chemical	Spacings	Swamp privet	Eastern persimmon	Green ash
	(cm)	(%)	(%)	(%)
			June applications	
2,4-D	2.5	86 ab	98 a	100 a
	8	80 b	99 a	100 a
	13	67 b	96 a	99 a
	Average	78	98	100
2,4-D + picloram	2.5	96 a	95 a	100 a
	8	91 a	100 a	100 a
	13	74 b	100 a	100 a
	Average	87	98	100
			September applications	
2,4-D	2.5	84 a	79 b	100 a
	8	87 a	67 b	97 b
	13	74 b	59 b	99 ab
	Average	82	68	99
2,4-D + picloram	2.5	91 a	100 a	100 a
	8	91 a	100 a	100 a
	13	80 a	97 a	94 c
	Average	87	99	98
			December applications	
2,4-D	Edge-to-edge	77 ab	100 a	100 a
	2.5	71 b	70 b	100 a
	8	47 c	56 b	100 a
	Average	65	75	100
2,4-D + picloram	Edge-to-edge	93 a	100 a	100 a
	2.5	94 a	100 a	100 a
	8	80 ab	99 a	100 a
	Average	89	100	100

[a]For a given species and month, values for spacings and chemicals followed by the same letter do not differ significantly at the 0.05 level. A separate standard error was used for calculating the range for comparing averages for each month.

In September 2,4-D was effective only on green ash, where it performed well even at the 13-cm spacing. The chemical mixture was successful at 13-cm on eastern persimmon and green ash and at 8-cm on swamp privet.

December applications of 2,4-D failed on swamp privet, succeeded in edge-to-edge spacings on eastern persimmon, and gave excellent results on green ash at 8-cm spacing, the widest tested. The chemical mixture was very effective on swamp privet at 2.5-cm spacings and on the other two species at 8-cm spacings.

Discussion

This study, in connection with previous research, establishes that injection of undiluted herbicides is effective in controlling many hardwood species on bottom-land sites.

In Table 4 are summarized the dosages and injection spacings that, in the author's judgement, provide the best control per dollar of expenditure. Crown kill for treatments listed ranged from 86 to 100%. When equally ef-

Table 4. Optimum effective spacings and dosages for each species and month.

Species	June			September			Winter		
	Chemical	Dosage	Spacing	Chemical	Dosage	Spacing	Chemical	Dosage	Spacing
		(ml)	(cm)		(ml)	(cm)		(ml)	(cm)
Elm	2,4-D	1	23	2,4-D	1	23	2,4-D	1	18
Overcup oak	2,4-D	2	18	2,4-D	1	23	2,4-D	1	18
Pecan	2,4-D	1	8	2,4-D	1	18	2,4-D + picloram	1	8
American hornbeam	2,4-D	1	8	2,4-D	1	13	2,4-D	1	2.5
Hawthorn	2,4-D	1	8	2,4-D	1	13	2,4-D	1	8
Swamp privet	2,4-D + picloram	1	8	2,4-D + picloram	1	8	2,4-D + picloram	1	2.5
Eastern persimmon	2,4-D	1	13	2,4-D + picloram	1	13	2,4-D + picloram	1	8
Green ash	2,4-D	1	13	2,4-D	1	13	2,4-D	1	8

fective, 2,4-D is listed in preference to 2,4-D and picloram, because it is cheaper.

If injector crews are not trained to recognize species and vary treatments accordingly, all trees must be treated like the most resistant in the stand. For the eight species listed in Table 4, general-purpose prescriptions would be:

Spring: 1 ml of 2,4-D at 8-cm spacing. Where swamp privet is numerous, substitute the mixture of 2,4-D and picloram at the same dosage and spacing.

Fall: 1 ml of 2,4-D at 13-cm spacing. Where swamp privet and eastern persimmon are numerous, use the chemical mixture at the same dosage and spacing.

Winter: 1 ml of 2,4-D at 8-cm spacing. Where swamp privet, eastern persimmon, and pecan are numerous, use the chemical mixture at the same dosage and spacing.

If resistant species are a minor component of the stand, it may be more practical to treat them with edge-to-edge injections of 2,4-D than to switch to the mixed chemical.

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