Spray Date Effects on Behavior of Herbicides on Brush[1]

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Abstract. Dicamba (3,6-dichloro-*o*-anisic acid), 1,1′-dimethyl-4,4′-dipyridinium ion (paraquat), and (2,4,5-trichlorophenoxy)-acetic acid (2,4,5-T) were applied as foliar sprays to 4-year-old sweetgum *(Liquidambar styraciflua* L.), green ash *(Fraxinus pennsylvanica* Marsh.), water oak *(Quercus nigra* L.), and loblolly pine *(Pinus taeda* L.). For the three hardwood species the amount of herbicide absorbed and translocated, as measured 4 days after application, was correlated closely with tops killed 1 year later. Applications in May were more effective than those made later in the growing season. Loblolly pine was defoliated by all herbicides but recovered the second season after spraying.

INTRODUCTION

FOLIAR spraying is a technique used in forestry to release young pines from competing hardwoods or to kill all woody plants in order to clear sites for establishment of new tree crops. In the first situation, the herbicide must be lethal to hardwoods and nonphytotoxic to pine.

From tests conducted in Louisiana, Burns[3] recommended that foliar spraying for removal of competing brush to release pine be done in May or early June. Badiei *et al.* (1) found that in Oklahoma absorption and translocation of (2,4,5-trichlorophenoxy)acetic acid (2,4,5-T) by blackjack oak *(Quercus marilandica* Muenchh.) was highest in May, decreased through July, and remained low for the remainder of the season. Limited killing of mixed brush achieved with July and August sprays by Brady *et al.* (2) may have been due to poor absorption, translocation, or both.

In the study reported here, the purpose was to determine if killing woody species is correlated with absorption and translocation and whether changes in season of application affect each in the same way.

METHODS AND MATERIALS

Three hundred and eighty-four plants each of loblolly pine *(Pinus taeda* L.), sweetgum *(Liquidambar styraciflua* L.), green ash *(Fraxinus pennsylvanica* Marsh.), and water oak *(Quercus nigra* L.) were selected to represent a crop species and susceptible, intermediate, and somewhat resistant brush species, respectively. The plants were divided into 96 plots of each species. Half the plots contained three trees, and half had five. Hardwoods averaged slightly more than 1 m while pines were about 2 m tall.

Water solutions of 3,6-dichloro-*o*-anisic acid (dicamba), 1,1′-dimethyl-4,4′-dipyridinium ion (paraquat), and a propylene glycol butyl ether ester of 2,4,5-T were prepared at a concentration that would supply 2.24 kg/ha of herbicide when 20 ml were sprayed on the five-tree plots. Enough ^{14}C-labeled herbicide was added to the solutions to be sprayed on the three-tree plots to provide 0.3 μC of radioactivity per plot. The label was in carbon one of the acetic acid moiety of 2,4,5-T, the carboxylic acid carbon of dicambe, and the 1-methyl group of paraquat.

The five-tree plots were sprayed with a broadcast application of 20 ml per plot May 3, June 7, July 19, or September 6, 1968. These plants were retained and used for measurements of plant tops killed. On the same dates, one side of each tree in the three-tree plots was enclosed in a large plastic bag while the other side was sprayed with 5 ml of one of the ^{14}C-labeled spray solutions. These plants were used for the absorption and translocation measurements. Treatments were replicated four times on each species.

Ninety-six hours after application of the labeled herbicides, samples were taken from foliage on the sprayed and unsprayed sides and the roots of each plant. Five-gram portions of each sample were analyzed for ^{14}C activity. The method of Clark *et al.* (3) was used for extraction and cleanup of 2,4,5-T. The method of Tye and Engel (4) was modified for dicamba in plant materials. The Chevron Chemical Company[4] procedure was used for extraction and cleanup of paraquat. Suitable blanks, checks, and standards were included in each analysis procedure.

The ^{14}C activity of the sample was measured by liquid scintillation counting. Corrections for background and quenching were made and corrected data reported. The above techniques produce a sample in which no metabolites of the herbicide in question are detectable by conventional chemical methods. However, the sensitivity of radioactive counting is much greater than colorimetric or chromatographic determinations. It is possible that traces of metabolites were included in total counts, but in order for metabolites to be present the herbicide must first be absorbed. The presence of traces of metabolites of labeled herbicides in the samples could not influence the results of the study.

Since it is impractical to analyze entire plants of the size used here, values reported are the activity recovered from 5 g of each plant part. Lateral translocation was measured by the activity in untreated foliage and basipetal movement by that in the roots. The ^{14}C counts from the three samples from a treated plant were combined for the comparison of total absorption.

RESULTS AND DISCUSSION

Tops killed, absorption, and translocation varied with herbicide, time of application, and species (Tables 1, 2, and 3). Average tops killed by 2,4,5-T ester exceeded 80%

[1]Received for publication June 19, 1970.

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[3]Burns, P. Y. 1959. Recommendations for aerial spraying of hardwoods to release pines. La. State Univ. Forest. Notes 28, 2 p.

[4]Analyses of Paraquat Residues Method RM-8. File 740.10. January 30, 1970. Chevron Chemical Company, Ortho Division, Research and Development Department, Richmond, California.

Table 1. Effects of date of spraying on tops of sweetgum killed and absorption and translocation of three herbicides.

Herbicide and spray date	Tops killed (%)	Absorption (cpm/5 g)	Lateral trans-location (cpm/5 g)	Basipetal trans-location (cpm/5 g)	Total trans-location (cpm/5 g)
2,4,5-T					
May 3	100 a	2,161 c	253 a	236 a	489 ab
June 7	100 a	22,055 a	278 a	297 a	575 a
July 19	100 a	6,659 b	214 a	166 a	380 b
Sept. 6	100 a	6,163 b	431 a	167 a	598 a
Dicamba					
May 3	98 a	2,750 b	159 a	184 a	343 a
June 7	66 b	7,717 a	164 a	258 a	422 a
July 19	52 b	3,699 b	115 a	190 a	305 a
Sept. 6	22 c	4,903 ab	66 a	265 a	331 a
Paraquat					
May 3	77 a	550 a	66 a	89 a	155 a
June 7	44 b	2,088 a	112 a	59 a	171 a
July 19	39 b	1,249 a	77 a	65 a	142 a
Sept. 6	28 c	461 a	64 a	67 a	131 a

[a]Within a column and for a single herbicide, values followed by the same letter are not significantly different at the 5% level (Duncan's new multiple range test).

Table 2. Effects of date of spraying on top of green ash killed and absorption and translocation of three herbicides.

Herbicide and spray date	Tops killed (%)	Absorption (cpm/5 g)	Lateral trans-location (cpm/5 g)	Basipetal trans-location (cpm/5 g)	Total trans-location (cpm/5 g)
2,4,5-T					
May 3	100 a[a]	7,214 b	271 a	147 a	418 a
June 7	97 a	21,924 a	133 ab	264 a	397 a
July 19	93 a	11,438 b	65b	145 a	210 b
Sept. 6	88 a	8,679 b	79 b	147 a	226 b
Dicamba					
May 3	97 a	3,038 b	425 a	225 a	650 a
June 7	87 a	21,224 a	252 b	204 a	456 b
July 19	84 a	18,718 a	186 b	148 a	334 b
Sept. 6	51 b	1,559 b	48 c	99 a	147 c
Paraquat					
May 3	69 ab	7,850 a	177 a	106 a	283 a
June 7	74 a	11,125 a	98 b	91 a	189 a
July 19	50 b	4,499 b	75 b	138 a	213 a
Sept. 6	44 b	690 c	74 b	133 a	207 a

[a]Within a column and for a single herbicide, values followed by the same letter are not significantly different at the 5% level (Duncan's new multiple range test).

Table 3. Effects of date of spraying on tops of water oak killed and absorption and translocation of three herbicides.

Herbicide and spray date	Tops killed (%)	Absorption (cpm/5 g)	Lateral trans-location (cpm/5 g)	Basipetal trans-location (cpm/5 g)	Total trans-location (cpm/5 g)
2,4,5-T					
May 3	95 a[a]	15,778 a	454 a	553 a	1,009 a
June 7	49 c	12,547 b	199 b	424 a	623 b
July 19	64 b	11,575 b	394 ab	270 b	664 b
Sept. 6	58 bc	8,622 c	46 b	298 b	344 c
Dicamba					
May 3	82 a	6,571 a	293 a	320 a	613 a
June 7	53 ab	6,078 a	432 a	396 a	828 a
July 19	41 b	6,207 a	230 ab	121 b	351 b
Sept. 6	42 b	3,491 b	137 b	106 b	243 b
Paraquat					
May 3	81 a	4,437 a	121 a	115 a	236 a
June 7	63 b	3,331 a	181 a	160 a	341 a
July 19	61 b	3,697 a	69 a	169 a	238 a
Sept. 6	60 b	2,978 a	132 a	133 a	265 a

[a]Within a column and for a single herbicide, values followed by the same letter are not significantly different at the 5% level (Duncan's new multiple range test).

for each of the four spray dates on all three hardwood species. Dicamba killed more than 90% of the tops of the three hardwood species when sprayed in May, but its effectiveness dropped rapidly with sprays applied in June, July, and September. Tops killed by paraquat were marginal in May and unsatisfactory for all other dates. The behavior of each of the three herbicides on each of the four species was somewhat different, making direct comparisons between herbicides and species impossible; therefore, the response of each species to each herbicide is discussed alone.

Sweetgum. All sweetgum plant tops were killed with 2,4,5-T applied on all four dates (Table 1). Absorption of 2,4,5-T was lowest in May and highest in June. The tenfold difference between these two dates was the largest found in the study. Neither lateral nor downward translocation varied significantly between dates, but total movement was less in July than in June and September.

Dicamba and paraquat were most lethal when sprayed in May. Later in the season, both failed to kill 75% of the sprayed plants which is considered the minimum acceptable level of effectiveness for foliar treatment. More dicamba was absorbed from applications in June than from those in May or July. This was somewhat unexpected since treatments in June were less effective than those in May. The comparison between killing plant tops and absorption of dicamba in sweetgum was one of only two relationships in this study where the correlation was not significant (Table 4).

Table 4. Simple and multiple correlation coefficients relating absorption and translocation of three herbicides with the tops of three hardwood species killed.

Species	Chemical	Absorption to tops killed (r)	Trans-location to tops killed (r)	Absorption plus translocation to tops killed (R)
Sweetgum	Dicamba	0.540[a]	0.803	0.866
	Paraquat	0.680	0.597	0.810
Green ash	2,4,5-T[b]	0.899	0.771	0.988
	Dicamba	0.838	0.964	0.993
	Paraquat	0.962	0.789	0.986
Water oak	2,4,5-T	0.947	0.955	0.995
	Dicamba	0.774	0.585	0.858
	Paraquat	0.933	0.620	0.959

[a]All values greater than 0.590 for the simple correlations and 0.646 for the multiple correlations are significant at the 5% level.

[b]Tops of all sweetgum plants killed by 2,4,5-T resulted on no variation in this variable. When one variable does not vary the correlation is undefined, i.e., $r = \frac{\Sigma\ x\ y.}{O}$

Absorption of paraquat was not significantly affected by date of application. Although lateral, basipetal, and total translocation did not change significantly with date of spraying, the correlation between tops killed and total movement was significant.

Green Ash. Date of spraying 2,4,5-T did not significantly affect tops of green ash killed, which ranged from 88 to 100% (Table 2). However, absorption was two to three times greater in June than on the other dates. Lateral and total translocation were higher in May than in July and September. Total movement was greatest in May and June.

For dicamba the three early dates were equally effective for controlling green ash, and all killed significantly more plants than the September treatment. Absorption was much greater with June and July application than on the other two dates. Lateral and total translocation were greatest from May treatment and decreased thereafter.

With paraquat, applications in June reduced the canopy more than did July and September treatments. May and June spraying also resulted in greatest absorption by green ash. Maximum lateral translocation occurred after the May spraying.

Correlations of tops killed with absorption and with total translocation were exceptionally high for all three herbicides (Table 4).

Water oak. Water oak was the most difficult of the three hardwood species to kill with 2,4,5-T and dicamba. Both of these chemicals along with paraquat satisfactorily killed tops only in May. Treatments with all three herbicides at later dates were significantly less effective. Absorption of 2,4,5-T also was superior in May and was better in June and July than in September. May applications resulted in more lateral movement of 2,4,5-T than did June and September treatments, while May and June were superior for basipetal translocation. Greatest total translocation was achieved with May sprays.

With dicamba, absorption and lateral translocation did not decrease significantly until September. Basipetal movement was highest in May and June. Total translocation was best in June and better in May than in July or September.

Absorption and translocation of paraquat did not differ significantly with date of spraying.

The close relationship between absorption and translocation of all three herbicides was demonstrated again in water oak (Table 4).

More plant tops were killed with each of the three herbicides on all three hardwood species from May sprays; therefore, this was the most favorable time to spray for hardwood control in Louisiana. Each of the herbicides was absorbed and translocated in different amounts by each species. Date of spraying also affects absorption and translocation differently in each species, but if these limitations are recognized and considered, absorption and translocation measurements can provide useful indications of the ultimate effectiveness of a herbicidal spray.

Loblolly pine. Loblolly pine was defoliated by all herbicides on all dates of spraying. None of the treatments caused mortality, and by August 1969 all trees had refoliated. No doubt some loss of growth and vigor resulted, but this damage was not assessed.

Absorption of the ester of 2,4,5-T was highest in June and lowest in September, and it was greater in May than in July. Lateral and total translocation were higher in May than in September. Date of spraying did not affect basipetal movement.

With dicamba, basipetal and total translocation, as well as absorption, were higher after May and June sprays than after July and September sprays. Lateral movement was unaffected by date of spraying.

Absorption and translocation of paraquat were not affected by date of spraying.

ACKNOWLEDGMENT

The radioactive dicamba and paraquat used in this study were supplied by the Velsicol Chemical Company and Chevron Chemical Company. The commercial formulations of 2,4,5-T ester, dicamba, and paraquat were provided by the Thompson Hayward Chemical Company, Velsicol Chemical Company, and Chevron Chemical Company, respectively.

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Reprinted from **WEED SCIENCE, volume 19, number 3, pages 200-202. May 1971.**