CHEMICAL WEED CONTROL IN SOUTHERN FOREST NURSERIES

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INTRODUCTION

Increased production of hardwoods in southern forest nurseries has greatly increased the need for the development of modern chemical weed control practices since the standard mineral spirits applications are injurious to most hardwood seedlings.

A vast array of agronomic herbicides is available and the task of selecting ones suitable for use in forest nurseries must begin with a determination of the relative tolerance of important species to the materials available.

TOLERANCE STUDIES

Thirteen herbicides (table 1) were screened in the greenhouse on seedlings of six species: loblolly pine, slash pine, Arizona cypress, yellow-poplar, sweetgum, and sycamore. Tolerance studies on cottonwood were conducted with cuttings in the nursery, but the results of these studies are reported separately (Martin and Carter, 1966).

Sandy loam soil from the Auburn Forest Nursery was steam sterilized and placed in the greenhouse flats. Half of each flat was sown with a conifer and the other half with a hardwood. The species were paired as follows: loblolly pine with yellow-poplar, slash pine with sycamore, Arizona cypress with sweetgum. One hundred seeds of loblolly, slash, or sweetgum were planted per flat, whereas 200 seeds of the other species were used. After sowing, the seeds were covered with 1/4- to 1/2-inch of sawdust mulch and herbicides were sprayed or dusted over the surface of the sawdust. Flats were watered by surface application.

Six to 8 weeks after planting, data were collected on survival, height, and general appearance of the seedlings. With one exception, survival was found to be the best measure of tolerance. Herbicides causing injury symptoms also reduced survival except for Eptc, which produced needle malformations on the two pines without any other *signs* of injury.

Survival values for the six species are listed in tables 2, 3, and 4. The results are summarized in table 5. Several factors should be remembered when these results are interpreted. First, the soil used was a light sandy loam. When the clay content of a soil increases,

Table 1.--Chemicals used in the present investigation

Common: Formulation name	Chemical name	Trade name and supplier
Ametryne 50% wettable powder	2-ethylamino-4-isopropyl-amino-6-methylmercapto-s-triazine	Ametryne-Geigy Chemical Corp.
Atrazine 80% wettable powder	2-chloro-4-ethylamino-6-isopropylamino-s-triazine	Atrazine-Geigy Chemical Corp.
Chloroxuron 50% wettable powder	N'-4(4-chlorophenoxy) phenyl-N,N-dimethylurea	Tenoran - CIBA Corp.
Cotoran 80% wettable powder	N-(3-trifluoromethyl-phenyl)N,N' dimethylurea	Cotoran - CIBA Corp.
DCPA 5% granular	Dimethyl-2,3,4,6-tetra-chloroterephthalate	Dacthal - Diamond Alkali Co.
Dichlobenil 4% wettable powder	2,6-dichlorobenzylnitrile	Casoron-Thompson-Hayward Chemical Co.
Diphenamid 80% wettable powder	N,N-dimethyl-2,2-diphenyl-acetamide	Dymid-Eli Lilly & Co. (Elanco)
Diuron 80% wettable powder	3-(3,4-dichlorophenyl)-1, 1-dimethylurea	Karmex - E. I. DuPont de Nemours & Co.
DNBP 5 lbs/gal	dinitro-o-sec-butylphenol	Dow General Weed Killer - Dow Chemical Co.
Eptc 10% granular	ethyl-N,N-diprophylthiol carbamate	Eptam-Stauffer Chemical Co.
Norea 80% wettable powder	3-(hexahydro-4,7-methanio-dan-5-yl)-1, 1,dimethylurea	Herbam-Hercules Powder Co.
Paraquat 2 lbs/gal	1,1'-dimethyl-4, 4'-dipyridinium salt	Chevron Chemical Co.
Prometryne 80% wettable powder	2,4-bis(isopropylamino)-6-methyl-mercapto-s-triazine	Caparol-Geigy Chemical Co.
Simazine 80% wettable powder	2-chloro-4,6-bis(ethylamino)-s-triazine	Simazine-Geigy Chemical Co.
Trifluralin 4 lbs/gal	a,a,a,trifluoro-dinitro-N,N-dipropyl-p-toluidine	Treflan-Eli Lilly & Co.

Table 2.--Percent survival of loblolly pine and yellow-poplar seedlings following pre-emergence treatment with herbicides

Treatment chemical	Rate (pounds/acre)	Survival (%) Loblolly pine	Survival (%) Yellow-poplar
Control		71.0	11.4
Eptc	3	87.3	5.3
	6	87.0	1.5
DCPA	4	91.0	15.5
	8	86.6	13.3
Dichlobenil	4	-0-	-0-
	8	-0-	-0-
Simazine	3	30.3	6.3
	6	1.3	1.3
Atrazine	3	12.3	3.0
	6	-0-	1.1
Prometryne	3	12.3	9.5
	6	84.0	4.1
Ametryne	3	88.0	11.8
	6	72.6	2.6
Cotoran	2	49.3	8.8
	4	28.0	7.8
Chloroxuron	2	92.0	12.5
	4	91.6	13.8
Trifluralin	1	91.6	13.6
	2	86.6	11.6
Diphenamid	4	91.3	14.3
	8	93.0	14.0
Norea	1	94.6	15.0
	2	85.6	15.0
Diuron	1	55.3	11.6
	2	21.3	7.6

Table 3.--Percent survival of slash pine and sycamore seedlings following pre-emergence treatment with herbicides

Treatment chemical	Rate (pounds/acre)	Survival (%)	
		Slash pine	Sycamore
Control		73	7.1
Eptc	3	72	7.6
	6	59	2.7
DCPA	4	66	7.2
	8	75	7.0
Dichlobenil	4	0.2	0.1
	8	-0-	-0-
Simazine	3	59	-0-
	6	-0-	-0-
Atrazine	3	58	-0-
	6	22	-0-
Prometryne	3	78	0.7
	6	67	-0-
Ametryne	3	72	-0-
	6	61	0.1
Cotoran	2	59	1.0
	4	18	-0-
Chloroxuron	2	77	6.3
	4	72	6.3
Trifluralin	1	76	6.1
	2	77	4.0
Diphenamid	4	70	8.6
	8	72	5.2
Norea	1	74	6.8
	2	75	1.3
Diuron	1	70	0.5
	2	66	3.2

Table 4.--Percent survival of Arizona cypress and sweetgum seedlings following pre-emergence treatment with herbicides

Treatment chemical	Rate (pounds per acre)	Survival (%) Arizona cypress	Sweetgum
Control		13.0	56.4
Eptc	3	9.8	38.9
	6	8.5	13.0
DCPA	4	12.4	50.2
	8	10.0	58.7
Dichlobenil	4	-0-	-0-
	8	-0-	-0-
Simazine	3	1.2	13.2
	6	0.8	9.5
Atrazine	3	0.5	4.8
	6	0.2	2.2
Prometryne	3	4.9	53.3
	6	0.4	44.8
Ametryne	3	2.5	44.8
	6	0.6	50.2
Cotoran	2	7.7	53.8
	4	5.1	41.5
Chloroxuron	2	7.7	61.3
	4	10.2	46.7
Trifluralin	1	10.9	50.7
	2	10.2	56.3
Diphenamid	4	12.5	42.7
	8	8.8	64.7
Norea	1	11.4	52.5
	2	11.4	63.2
Diuron	1	2.8	52.2
	2	1.2	46.3

Table 5.--Treatments which appeared non-injurious in greenhouse trials

Chemical	Species and rate per acre					
	Loblolly pine	Slash pine	Arizona cypress	Yellow-poplar	Sweetgum	Sycamore
	- - - - - - - - - - Pound - - - - - - - - - -					
Eptc	3 and 6	4	-	-	-	3
DCPA	4 and 8	4 and 8	4 and 8	4 and 8	4 and 8	4 and 8
Prometryne	3 and 6	3 and 6	-	-	3 and 6	-
Ametryne	3 and 6	3 and 6	-	3	3 and 6	-
Chloroxuron	2 and 4	2 and 4	-	2 and 4	2 and 4	2 and 4
Trifluralin	1 and 2	1 and 2	1 and 2	1 and 2	1 and 2	1
Diphenamid	4 and 8	4 and 8	4 and 8	4 and 8	4 and 8	4
Norea	1 and 2	1 and 2	1 and 2	1 and 2	1 and 2	1
Diuron	-	1 and 2	-	1	1 and 2	-
Cotoran	-	-	-	-	2 and 4	-

the toxicity of many herbicides decreases because of binding of the herbicides by soil colloids. Therefore, the use of a heavier or lighter soil could have altered the results. The herbicides were applied to a sawdust mulch, which no doubt bound some of the chemicals. The use of a different mulching material could very well have changed the results (see Andus, 1964). The studies were conducted in greenhouse flats at high seedling densities which probably resulted in a greater amount of herbicide being absorbed per seedling than had studies been conducted under field conditions where root systems were less restricted. Hence, tolerances in the field would probably exceed those observed in the greenhouse. Field studies reported later bear out this prediction.

However, useful information can be drawn from the work. Dichlobenil, simazine, atrazine, and cotoran appear too toxic to be used as preemergence on the species tested. Several other materials show promise if good weed control can be obtained at safe rates of application. Yellow-poplar, sweetgum, and the two pines apparently have some resistance to several herbicides, but sycamore and Arizona cypress appear quite sensitive to most of the chemicals tested.

FIELD STUDIES

The results of the screening studies have been extensively field tested on only one species to date--yellow-poplar. The seven chemicals listed as promising for yellow-poplar in table 5 plus prometryne (which appeared only slightly injurious) were tested on 4-x 5-foot plots at the Auburn Forest Nursery (sandy loam soil). Each chemical was applied at two rates and replicated three times. Treatments were applied to sawdust mulched nursery beds that had been seeded 2 days earlier. Liquid formulations were applied with a hand sprayer, whereas, granular materials were applied with a large salt shaker.

The effectiveness of the weed control was evaluated on the basis of hand weeding time required for each plot. Plots were weeded May 3, June 7, and July 26. Height and density counts were made in early-December. Results are shown in table 6. Prometryne at 2 pounds per acre significantly reduced hand weeding time below the control without affecting seedling density or height growth. There were several apparent discrepencies in the data where the low rate of a chemical appeared to give better weed control than the high rate. Highly variable weed populations produced this result, and more replications were needed. The variation was so great that a reduction of nearly 50 percent in hand weeding time was necessary to be statistically significant at the 5 percent level.

Nevertheless, the results do indicate that appreciable savings can be attained through use of herbicides.

Additional work with dichlobenil was conducted because of excellent weed control obtained with this compound in preliminary trials. This

Table 6.--Effects of eight pre-emergence chemicals on weeding time, density, and height growth of yellow-poplar seedlings at the Auburn Nursery

Treatment	Rate (pounds per acre)	Average hand weeding time 1/ (man-hour per acre)2/	Average seedling density2/ (trees per foot)	Average seedling height2/ (foot)
Check		145.2	11.9	1.9
DCPA	8	115.0	10.6	2.1
	16	100.8	14.5	2.1
Prometryne	2	74.7*	14.2	2.2
	4	99.6	10.7	2.2
Ametryne	2	89.2*	9.1	1.9
	4	85.5*	9.2	2.2
Chloroxuron	3	94.7	12.6	2.5*
	6	131.0	13.5	2.3*
Trifluralin	2	92.8	10.3	2.2
	4	98.9	10.8	2.4*
Diphenamid	4	146.0	15.7	2.3*
	8	112.9	11.9	2.1
Norea	2	109.7	11.4	2.1
	4	83.1*	11.2	2.3*
Diuron	1	73.8*	11.6	2.0
	2	88.7*	8.3	2.0

1/ Total hand weeding time for three weedings based on acres of actual nursery bed exclusive of alleys.

2/ Averages followed by an asterisk are significantly different from the check at the .05 level (Duncan, 1955).

chemical is quite active in the vapor state and is most effective against weed seed (Andus, 1964). However, screening studies indicated nearly complete mortality for all tree species when dichlobenil was applied to seedbeds (tables 2, 3, and 4). Therefore, studies were carried out on young seedlings shortly after germination.

Treatments of dichlobenil at 0, 4, 8, and 16 pounds per acre were applied after the first hand weeding. The granular material was applied with a large salt shaker. Each treatment was replicated four times in a randomized block design. Hand weeding time, density, and height measurements were taken as described in the pre-emergence study.

Studies on yellow-poplar and sycamore were conducted at the Auburn Nursery. Dichlobenil treatments were applied May 20 to 4- x 5-foot plots. At time of treatment, yellow-poplar seedlings were 3 to 4 inches high, while sycamore seedlings were 1 to 2 inches high. Yellow-poplar plots were hand weeded June 7 and July 26. Sycamore plots were hand weeded June 17, July 20, and August 5.

Studies on sycamore, loblolly pine, and willow oak were conducted at the Kimberly-Clark Nursery near Childersburg, Alabama. These studies were designed as described above except 4- x 10-foot plots were used for sycamore and loblolly pine. The dichlobenil treatments were applied June 3, 1965. At this time the seedling height averaged 2.5 inches, 3 inches, and 5.5 inches for sycamore, pine, and willow oak, respectively. The sycamore plots were weeded June 21 and August 3, and willow oak plots were weeded August 3.

Dichlobenil was highly toxic to young loblolly pine. By June 21, four pounds per acre of dichlobenil bad caused an estimated 60-70 percent mortality while 8 and 12 pounds per acre killed over 90 percent of the seedlings.

In all studies, dichlobenil significantly reduced hand weeding time when compared with the check (tables 7 and 8). No significant difference was apparent in weeding time between the three rates of chemical in studies on yellow-poplar and willow oak, but a significant difference was observed in 4 and 8 pounds per acre rates on both sycamore studies. Dichlobenil at 8 and 12 pounds per acre significantly reduced survival in yellow-poplar and willow oak; in the sycamore studies, dichlobenil significantly reduced survival only at 12 pounds per acre. Considerable mortality was noted on check plots in December at the Kimberly-Clark Nursery. These dead seedlings were 5 to 6 inches high, very spindly, and were apparently shaded by the dominant seedlings in the plots. The low density counts observed in check plots at the Kimberly-Clark Nursery were probably because of this observed natural mortality. This apparent natural mortality was not observed at the Auburn Nursery even though seedling density was much higher. Height growth was not affected by dichlobenil in any of the studies.

Table 7.--Effects of a post-emergence application of dichlobenil on hand weeding time, density, and height growth of seedlings at the Auburn Nursery

Treatment	Average hand weeding time 1/ 2/ (man hour per acre)	Average seedling density 2/ (trees per foot)	Average height 2/ (foot)
	YELLOW-POPLAR		
Check	86.6 a	12.4 a	2.1 a
Dichlobenil 4-G 4 lb./A	49.4 b	9.8 a	2.2 a
Dichlobenil 4-G 8 lb./A	44.6 b	3.9 b	1.9 a
Dichlobenil 4-G 12 lb./A	33.2 b	1.2 b	2.2 a
	SYCAMORE		
Check	672.0 a	16.5 a	1.7 a
Dichlobenil 4-G 4 lb./A	316.0 b	14.7 a	1.8 a
Dichlobenil 4-G 8 lb./A	268.0 bc	12.7 a	1.8 a
Dichlobenil 4-G 12 lb./A	178.0 c	4.7 b	1.9 a

1/ Total hand weeding time for three weedings based on acres of actual nursery bed exclusive of alleys.

2/ Averages followed by the same letter are not significantly different at the .05 level (Duncan, 1955).

Table 8.--Effects of a post-emergence application of dichlobenil on hand weeding time, density, and height growth of seedlings at the Kimberly-Clark Nursery

Treatment	Average hand weeding time 1/ 2/ (man hours per acre)	Average seedling density 2/ (trees per foot)	Average height 2/ (foot)
	SYCAMORE		
Check	40.0 a	6.20 a	3.1 a
Dichlobenil 4-G 4 lb./A	23.6 b	6.90 a	3.0 a
Dichlobenil 4-G 8 lb./A	17.0 bc	6.40 a	2.9 a
Dichlobenil 4-G 12 lb./A	12.2 c	3.85 b	3.0 a
	WILLOW OAK		
Check	15.8 a	5.90 a	1.4 a
Dichlobenil 4-G 4 lb./A	11.6 b	5.00 ab	1.3 a
Dichlobenil 4-G 8 lb./A	9.2 b	3.50 bc	1.2 a
Dichlobenil 4-G 12 lb./A	10.6 b	2.70 c	1.2 a

1/ Total hand weeding time for three weedings based on acres of actual nursery bed exclusive of alleys.

2/ Averages followed by the same letter are not significantly different at the .05 level (Duncan, 1955).

It appears that dichlobenil is safe for use at 4 pounds per acre for weed control in yellow-poplar, sycamore, and willow oak seedlings. Slightly higher rates might be used on sycamore since it appears to be more tolerant than the other two species.

The 4 percent granular formulation of dichlobenil should be used since the majority of the 50 percent wettable formulation will be quickly lost when applied to the soil surface in warm weather. Germination should be complete and the existing weeds removed by hand weeding prior to application of dichlobenil.

DISCUSSION AND CONCLUSIONS

This study investigated less than 20 of the dozens of herbicides available for use. Such studies must continue since new materials are appearing each year and costs and returns in the nursery business are continually changing.

At least four compounds are worthy of further testing for southern tree seedling production--prometryne, ametryne, norea, and diuron. Dichlobenil also appears useful if applied after germination.

Trifluralin and diphenamid may be worth of further test. Trifluralin is a volatile compound and best results are obtained when the material is incorporated into the soil. However, incorporation would probably increase seedling injury.

While pre- and post-emergence herbicides appear quite useful, it is clear that they are not going to eliminate hand weeding, particularly where a heavy seed population exists. Most agronomic herbicides are designed to act against light-seeded weeds germinating at or near the soil surface and to permit the deep-rooted crop seedlings to emerge without injury. The majority of desirable tree species are light-seeded and are planted on the soil surface where most herbicides are most active.

Where severe seed populations have built up, the only successful answer is soil fumigation followed by an intensive sanitation campaign against re-invasion. Weeds along fences, alleys, irrigation lines, ditches, and roads should be eliminated or kept well under control. Atrazine at 8 and 12 pounds per acre has proven quite effective in retarding weed growth on such areas. Even nut-sedge may be controlled by this material. Care must be taken to keep the material off nursery beds. Paraquat and DNBP are effective contact herbicides and are also useful in a sanitation program. All mulch and organic matter (e.g. sawdust, bark) should be fumigated to eliminate weed seed.

Nurseries should be fumigated in blocks as large as possible, preferably the entire nursery. Contamination from unfumigated areas should be controlled by cleaning all tractors, implements, and other objects that might transport weeds to the fumigated area. If irrigation water comes from ponds or streams, this is a potential source of seed that will probably have to be tolerated.

Once fumigation has reduced the weed population to low levels, judicious use of herbicides and strict sanitation practices should maintain the weed populations at a level where very little hand weeding is needed.

Fumigation is expensive, but the cost should be prorated over 3 to 5 years. This series of studies indicates that fumigation is the only good solution to severe weed problems.

Acknowledgment

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Discussion

Q. (Walls) Have you had any experience with the organic arsenicals?

A. (Carter) Very little.

Q. (Walls) Which ones have you used?

A. (Carter) We have only used DMSA.

Q. What about a surfactant with substituted ureas, such as Karmex?

A. (Carter) We haven't tried these with surfactants. I assume you mean to use the surfactant in the spray for post-emergence weed control.

COMMENTS (Walls). Yes. Dupont has put out a new material which might interest you. It is called Lorox. This is a linuron substance which offers pre-emergence control by itself. It also kills weeds and grasses post-emergence. It can be applied to carrots and kill the weeds and grasses without bothering the carrots.

COMMENTS (Carter). Once we try rows, there are many possibilities for weed control. A shielded sprayer is used in cotton. The spray is kept off the cotton by the shield and is put right down on the soil on either side of the cotton. Many of our problems are similar to the agronomist. We are dealing with light—seeded species which are planted on the surface; therefore, we are asking a chemical to do what it isn't designed to do.