Forest Tree Nursery Herbicide Studies at the Oklahoma Forest Regeneration Center[1]

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Abstract.--Eight herbicides (registered for similar uses in the U.S.) were extensively evaluated at the Forest Regeneration Center, Oklahoma Forestry Division, Washington, Oklahoma, for weed control on first year seedling nursery beds. Phytotoxicity evaluations of dcpa, napropamide, oxyfluorfen, diphenamid, bifenox, oxadiazon, trifluralin and prometryn on 19 different conifer and hardwood species are presented.

Additional key words: Enide®, Treflan®, Dacthal®, Caparol®, Devrinol®, Modown®, Goal®, and Ronstar®.

INTRODUCTION

The USDA Forest Service developed a number of nursery herbicide projects in the United States out of a recognition of the potential benefits of herbicidal control of weeds in nursery seedbeds. This paper will concentrate on projects conducted at the Forest Regeneration Center, Oklahoma Forestry Division. Washington, Oklahoma. The Oklahoma tree nursery was part of the following projects. The cooperative western nursery herbicide project, initiated in 1976, with cooperation among state, private and federal nurseries, Forest Service Research, State and Private Forestry, National Forest Systems, and State University of New York out of Syracuse. Twenty-eight nurseries in 12 states were involved in this effort which was broken down into three segments, each of three-year duration: the Pacific Coast started in 1976 (Stewart 1977, Owston et al. 1980, Owston and Abrahamson 1984), the Intermountain-Great Basin in 1977 (Ryker and Abrahamson 1980), and the Great Plains in 1978 (Abrahamson 1981, Abrahamson and Burns 1979) which the Oklahoma Nursery was a part of. In 1979 the Northeastern (NE) Area started an eastern nursery herbicide project in five states cooperating with Purdue University and State University of New York (SUNY) at Syracuse (Holt and Abrahamson 1980). In 1981 the NE Area expanded the eastern nursery herbicide project to the Great Lakes area with eight nurseries (state, federal and private) in three Lake States cooperating with SUNY (Abrahamson and Jares 1984).

During 1982, after the Great Plains segment of the cooperative western nursery herbicide project was completed, Oklahoma State (Abrahamson 1983) sponsored a nursery herbicide project of their own in cooperation with SUNY to help the nursery expand on the herbicide studies using different herbicides, tree species and sowing times. This study has continued on a yearly basis through 1987-88.

What is important in these projects is that all studies have similar objectives and methodologies and that information developed from one region or study project is supportive of that from other regions. In all these studies the objectives were to identify promising herbicides, develop data for product registration, and demonstrate safe and effective weed control practices for nursery seed beds.

METHODS

The nursery herbicide screening and demonstration projects were initiated as part of a three-year study. During the first year of the three-year study up to ten herbicides (eight of which are represented in Table 1) were screened on two to four major species of spring- and/or fall-sown conifers and/or hardwoods depending on the year involved in the study.

Treatments were applied to three- or six-foot long plots in four-foot wide nursery beds with a one-foot untreated buffer between plots. All treatments were installed in a randomized block design with three replications per species. Herbicides were applied with a modified Hudson®

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Table 1. Herbicides, rates, and application timings used in the Nursery Herbicide Studies Conducted by SUNY at the Oklahoma Forest Regeneration Center.

Herbicide	Formulation	Manufacturer	(lb ai/A)	Application Timing Inc[1]	or Ps[2]	Pg[3]	Ps + Pg[4]
Diphenamid	Enide 50W; 90 W	Nor-Am	4.0		x	x	x
Trifluralin	Treflan 4EC	Elanco	0.75		x	-	-
DCPA	Dacthal W-75	SBS Biotech	10.5		x	x	x
Prometryn	Caparol 80W	Ciba-Geigy	1.0		x	x	x
Napropamide	Devrinol 50W	Stauffer	1.5/3.0		x	x	x
Bifenox	Mowdown 80W; 4F	Rhone-Poulenc	3.0		x	x	x
Oxyfluorfen	Goal 2E; 1.6E	Rhom & Haas	0.5		x	x	x
Oxadiazon	Ronstar G	Rhone-Poulenc	1.0		x	x	x
Napropamide & Bifenox	Tank Mix		1.0+3.0		x	x	x

[1]Pre-seeding incorporation: incorporated into top 2 inches of soil immediately before seeding.

[2]Post-seeding: broadcast applied to soil immediately after seeding.

[3]Post-germination: broadcast applied to soil 4 to 5 weeks after seedling emergence.

[4]Post-seeding plus post-germination: two separate applications at the full recommended rate.

type pressure hand sprayer, or a modified AZ plot pressurized sprayer equipped with check valves and four flat fan 8001 nozzles operated at 20 psi in a water carrier at a volume equivalent to 85 ppa (100 ml/three-foot plot). Granular formulations were ocularly applied from a hand shaker uniformly over the plot.

Pre-seeding incorporated treatments were applied no more than one day before seeding and incorporated into the top two inches of soil using a garden rake. Post-seeding treatments (Ps) were applied within two days after seeding, except on the fall-sown species which were applied any time after fall seeding but before mulching. Post-germination treatments (Pg) were applied four to six weeks after seedling emergence, except on the fall-sown species which were applied in the spring after seedlings had emerged.

Herbicidal damage to conifers/ hardwoods at the end of the first growing season was evaluated using a ten-point rating scale (0 is complete kill, 10 is no effect) proposed by Anderson (1963). Height of nine randomly selected seedlings and number of seedlings per foot in three randomly selected rows in each plot were also measured to determine chemical effects on germination, seedling growth and survival.

The objectives of the second-year studies were to evaluate the phytotoxicity and weed control effectiveness of three to four herbicides screened from the first-year study to be non-phytotoxic to the species tested and have reasonable weed control of weeds present at that nursery. Phytotoxicity was evaluated by using herbicidal damage ratings (Anderson 1963), seedling survival (number/foot) and height growth (cm). Dosages of 1X, 2X, and 1X + 1X of these herbicides were applied post-seeding and/or post-germination using three- or six-foot long plots in four-foot wide beds with a one-foot untreated buffer between plots. All treatments were installed using a randomized block design with three replications per species. Herbicide treatments were applied by small pressurized sprayer or hand shaker as was done the first year of these studies.

During the Great Plains part of the Oklahoma studies, weed control effectiveness of the best treatments were evaluated under operational use using nursery application equipment on 100-foot test plots. The herbicides were evaluated for weed control under operational use at the 1X rate of application applied post-seeding along, or post-seeding and post-germination. Phytotoxicity rating, survival and height measurements were also recorded from these operational plots.

RESULTS AND DISCUSSION

Earlier results from the Oklahoma nursery studies has been reported in a similar manner (Abrahamson 1984, 1986). Phytotoxicity data from all Oklahoma studies through 1987 is presented in Tables 2-12, listed by herbicides tested under each species. The tables are summaries of all the phytotoxicity studies and indicate; 1) those fall- and/or spring-sown seedlings where the herbicide has been safely applied at rates indicated without stunting or germination reduction (x); 2) herbicides that appear to be promising at rates indicated, but because of possible phytotoxic problems implied in some of our studies, these should be thoroughly tested before using at your nursery (o); 3) herbicides that should not be used

at rates indicated because of severe phytotoxic damage (-). One herbicide that should be elaborated on is napropamide. Napropamide is used at the lower rate (1.5 lbs ai per acre) when the nursery soil has below 1 percent organic matter, otherwise the higher rate (3.0 The ai per acre) is normally used. Napropamide is safe to use post-seeding on most spring-sown conifer species tested, but caused severe stunting when applied post-seeding to fall-sown conifer species in the Lake States study. Napropamide applied post-germination to both spring- and fall-sown conifers caused no phytotoxic problems.

Weed control expressed in terms of hand-weeding time, or "how much time can herbicides save you versus hand-weeding" is one of the most important aspects of these studies. In the Great Plains study (Abrahamson 1981) on spring-sown species the post-seeding applications were as effective as the post-seeding plus post-germination applications for total season weed control. The Forest Regeneration Center in Oklahoma is an example (Abrahamson 1983) of the type of savings in time and money that can be expected from these herbicides when used in forest tree nurseries.

Hand weeding time at the Oklahoma Forest Regeneration Center during 1981 was reduced by an average of 80 percent for all herbicides applied only in the spring (Ps) while those applied in both the spring and a second application five to six weeks later (Ps + PS) reduced hand weeding time by an average of 87 percent. Based on minimum wage of $3.35 per hour, this would amount to an average gross saving of $4,600 per acre of seedbed (without figuring in cost of herbicide or application costs) weeded six times with a mean weeding time of 283 man hours per acre untreated seedbeds at Norman (Abrahamson 1983).

SUMMARY

There have been numerous trials, studies and tests of various herbicides at many different nurseries that have demonstrated the safe and effective use of dcpa, napropamide, oxyfluorfen, diphenamid, bifenox, oxadiazon, trifluralin, and prometryn on various conifer and/or hardwood first year seedling nursery beds. These herbicides have reduced the time required to hand-weed nursery beds by 80-87 percent when applied at sowing time alone or with a second application four to six weeks later. Over $4,000-$7,000 per acre of seedbed could be saved by using these herbicides over hand-weeding alone.

However, the safety and effectiveness of any herbicide should be tested at each nursery before operational use. These herbicide trials are urged because there is a strong possibility of differential results from varied interactions of different mixtures of tree and weed species, soil and climatic factors, and cultural practices at different nurseries. If a particular herbicide has never been used at your nursery, several years of trials are advisable because of variations in effects caused by different weather conditions. Trials should include "double doses" to evaluate the safety limits on crop seedlings and leave an untreated control to properly evaluate the effects of the herbicide.

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TABLE 2: Phytotoxic effects of herbicides tested on first year loblolly, shortleaf and Austrian pine nursery beds.

LOBLOLLY PINE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		x	x	x
oxyfluorfen	*		x	x	x
diphenamid	*		x	x	x
bifenox	*		o	x	o
trifluralin	*		x		
napropamide & bifenox	*		o	x	o

SHORTLEAF PINE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
napropamide	*		x		
oxyfluorfen	*		x		
bifenox	*		x		
napropamide & bifenox	*		x		

AUSTRIAN PINE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		x	x	x
oxyfluorfen	*		o	x	o
diphenamid	*		x	x	x
bifenox	*		o	x	o
trifluralin	*		x		
napropamide & bifenox	*		o	x	o

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 3: Phytotoxic effects of herbicides tested on first year ponderosa and Scotch pine nursery beds.

PONDEROSA PINE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		x	x	x
oxyfluorfen	*		x	x	x
diphenamid	*		x	x	x
bifenox	*		x	x	x
oxadiazon	*		x	x	x
trifluralin	*		x		
napropamide & bifenox	*		x	x	x

SCOTCH PINE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa		*	x	x	x
napropamide		*	x	x	x
oxyfluorfen		*	x	x	x
diphenamid		*	x	x	x
bifenox		*	x	x	x
oxadiazon		*	x	x	x
trifluralin		*	x		
prometryn		*	x	x	x

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 4: Phytotoxic effects of herbicides tested on first year eastern red cedar, and white cedar nursery beds.

EASTERN RED CEDAR

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa		*	x	x	x
napropamide		*	x	x	x
oxyfluorfen		*	x	x	x
diphenamid		*	x	x	x
bifenox		*	o	x	o
oxadiazon		*	x	x	x
trifluralin		*	x		
napropamide & bifenox		*	o	x	o

WHITE CEDAR

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa		*	o	x	o
napropamide		*	o	x	o
oxyfluorfen		*	-	x	-
diphenamid		*	x	x	x
bifenox		*	-	x	-
oxadiazon		*	x	x	x
trifluralin		*	x		

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 5: Phytotoxic effects of herbicides tested on first year black walnut, and pecan nursery beds.

BLACK WALNUT

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa		*	x	x	x
napropamide		*	o	x	o
oxyfluorfen		*	o	o	o
diphenamid		*	x	x	x
bifenox		*	x	x	x
oxadiazon		*	x	x	x
trifluralin		*	x		

PECAN

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa		*	x	x	x
napropamide		*	x	x	x
bifenox		*	x	o	o
prometryn		*	x	o	o
napropamide & bifenox		*	x	o	o

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 6: Phytotoxic effects of herbicides tested on first year euonymus, and hackberry nursery beds.

EUONYMUS

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa		*	x	x	x
napropamide			x	x	x
diphenamid		*		o	
oxadiazon		*		x	
bifenox		*	o		
prometryn		*	o		
napropamide & bifenox		*	o		

HACKBERRY

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa		*		_	-
napropamide		*		x	
diphenamid		*	o	x	o
oxadiazon		*		x	

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 7: Phytotoxic effects of herbicides tested on first year lacebark elm, and sycamore nursery beds.

LACEBARK ELM

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		o	x	
napropamide	*		o	x	o
oxyfluorfen	*		-		-
diphenamid	*		-	o	-
bifenox	*		-	o	-
oxadiazon	*			x	
prometryn	*		-	-	-
trifluralin	*		o		
napropamide & bifenox	*		-	o	-

SYCAMORE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		-	x	-
napropamide	*		o	x	o
oxyfluorfen	*		-		-
diphenamid	*		o	x	o
bifenox	*		-	o	-
oxadiazon	*			x	
prometryn	*		-	-	-
trifluralin	*		o		
napropamide & bifenox	*		-	o	-

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 8: Phytotoxic effects of herbicides tested on first year redbud, catalpa, and silver maple nursery beds.

REDBUD

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		-	x	-
diphenamid	*			x	
bifenox	*		o	o	o
oxadiazon	*			x	
prometryn	*		x		
trifluralin	*		o		
napropamide & bifenox	*			o	

CATALPA

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*			x	
napropamide	*		x	x	x
diphenamid	*			x	
oxadiazon	*			x	
prometryn	*		x		
trifluralin	*		-		

SILVER MAPLE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		-	x	-
napropamide	*		x	x	x
oxyfluorfen	*		-		-
diphenamid	*		-	o	-
bifenox	*		-	o	-
oxadiazon	*			x	
prometryn	*		x	-	-
trifluralin	*		-		
napropamide & bifenox	*		-	o	-

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 9: Phytotoxic effects of herbicides tested on first year green ash, Russian olive, and black locust nursery beds.

GREEN ASH

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		x	x	x
diphenamid	*		x	x	x
bifenox	*		o	o	o
prometryn	*		x		
oxadiazon	*			x	
trifluralin	*		o		
napropamide & bifenox	*		-	o	-

RUSSIAN OLIVE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		x	x	x
diphenamid	*		x	x	x
bifenox	*		-	x	-
trifluralin	*		x		
napropamide & bifenox	*		-	x	-

BLACK LOCUST

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*			x	
napropamide	*		x	x	x
bifenox	*		o	o	o
prometryn	*		o		
oxadiazon	*			x	
trifluralin	*		-		
napropamide & bifenox	*			o	

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 10: Phytotoxic effects of herbicides tested on first year baldcypress, and osage-orange nursery beds.

BALDCYPRESS

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		x	x	x
bifenox	*		x	o	o
oxadiazon	*			x	
prometryn	*		o		
trifluralin	*		x		
napropamide & bifenox	*			o	

OSAGE-ORANGE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		o	x	o
bifenox	*		o	o	o
oxadiazon	*			x	
prometryn	*		x		
trifluralin	*		o		
napropamide & bifenox	*			o	

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 11: Phytotoxic effects of herbicides tested on first year mulberry, and autumn olive nursery beds.

MULBERRY

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		o	x	o
napropamide	*		-	x	-
bifenox	*		-	o	
oxadiazon	*			x	
prometryn	*		-		
trifluralin	*		x		
napropamide & bifenox	*			o	

AUTUMN OLIVE

Herbicide	Spring Sown	Fall Sown	Post-Seeding	Post-Germination	Post-Seeding & Germination
dcpa	*		x	x	x
napropamide	*		x	x	x
bifenox	*		x	x	x
oxadiazon	*			x	
prometryn	*		x		
trifluralin	*		x		
napropamide & bifenox	*			x	

x = no phytotoxic effects at nurseries tested.
o = some phytotoxic effects at one or more nurseries where tested requires additional trials before operational use.
- = severe phytotoxic effects, Do Not Use.

TABLE 12: Nursery summary of tree species and herbicides utilized in the Great Plains and Northern United States nursery herbicide studies from 1978 to 1987.

Nursery (Ownership)	Species Studied	Sown F/S	Herbicides Tested
Oklahoma Forest Regeneration Center [Norman Nursery] (State of Oklahoma)	Austrian Pine	S	DCPA
	Loblolly Pine	S	bifenox
	Shortleaf Pine	S	oxyfluorfen
	East. Red Cedar	F	trifluralin
	Black Locust	S	diphenamid
	Sycamore	S	napropamide
	Lacebark Elm	S	napropamide + bifenox
	Hackberry	F	oxadiazon
	Euonymus	F	prometryn
	Russian Olive[1]	F	butralin[1]
	Silver Maple	S	chloramben[1]
	Mulberry	S	chloroxuron[1]
	Pecan	F	
	Catalpa	S	
	Redbud	S	
	Autumn 0lve[1]	S	
	Green Ash[1]	S	
	Baldcypress[1]	S	
	Osage-orange[1]	S	

[1] Tested only one year or less.