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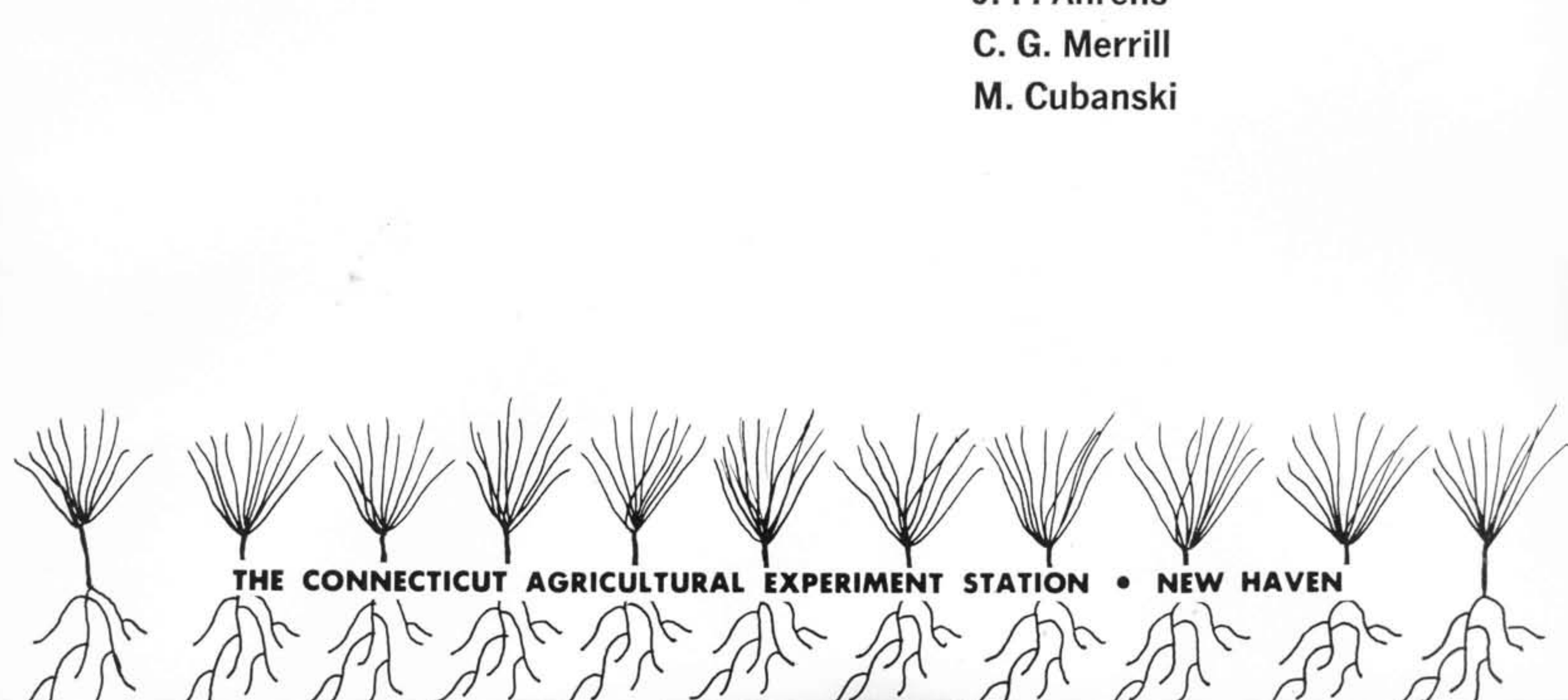

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION • NEW HAVEN

Herbicides for Conifer Seedbeds

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Twenty herbicides were evaluated in conifer seedbeds during 1970-75 at the Connecticut State Forest Nursery in Voluntown. Herbicides that caused the least injury to pine, spruce and Douglas-fir when applied about a month after germination were DCPA, diphenamid, napropamide and prometryn. These and simazine were effective without injury to second-year seedlings. Combinations of DCPA, diphenamid or napropamide with prometryn for first-year seedlings or with simazine for second-year seedlings controlled many species of weeds without significantly injuring seedlings. In large-scale trials, prometryn plus DCPA did not injure several species of second-year seedlings. Prometryn and simazine injured eastern hemlock, but DCPA did not. Simazine plus DCPA or prometryn plus DCPA markedly reduced weeding by hand.

INTRODUCTION

Weed control in conifer seedbeds traditionally has been by laborious and costly handweeding. In 1970 at the State Forest Nursery handweeding cost more than $1000 per acre when only mineral spirits were used to aid control. Mineral spirits are a contact herbicide, but are not effective against all weeds, have no residual activity, and must be applied repeatedly with increasing risk to conifer seedlings.

The ideal herbicide would kill weeds over a period of time without injuring conifer seedlings and without leaving residues that would harm succeeding crops. Although many herbicides have been tested in conifer seedbeds, varying soil and climate make local testing essential.

Conifers, like weeds, vary in sensitivity to herbicides, but are most sensitive to preemergence herbicides during early growth. Koslowski and Kuntz (6) found that red pine and white pine to a greater extent, became more tolerant of simazine, atrazine, and propazine with increasing age.

Other reports and our preliminary investigations indicate that simazine injures conifer seedlings in the first year but is safe during the second year (9, 10, 11).

Prometryn, trifluralin, DCPA, and diphenamid also kill weeds selectively in conifer seedbeds (4, 5, 7). Both DCPA and diphenamid have been widely used in ornamental plantings. Since they control annual grasses but fail to control several broadleaved weeds, they have been combined successfully with low rates of simazine, which controls broadleaved weeds (1). We also evaluated these and newer herbicides.

MATERIALS AND METHODS

Experiments were conducted first with second-year seedlings (2-0) and later with first-year (1-0) seedlings. Experiments on small plots were followed by trials on larger areas. The sandy loam soil had been amended through the years with wood chips and contained 5% organic matter.

Conifer seeds were broadcast or drilled on prepared beds in November and December and then covered with a mulch of pine needles. After the seeds germinated in late April, most needles were removed. During the first season the seedbeds were covered with a shade of plastic mesh or cheesecloth. If rain did not fall daily, the plots were irrigated to moisten and cool. The following species were included:

- white spruce — *Picea glauca* (Moench) Voss
- Norway spruce — *Picea abies* (L.) Karst
- Engelmann spruce — *Picea engelmannii* (Parry) Engelmann
- white pine — *Pinus strobus* L.
- Scotch pine — *Pinus sylvestris* L.
- Japanese black pine — *Pinus thunbergiana* Franco
- red pine — *Pinus resinosa* Ait.
- Douglas-fir — *Pseudotsuga menziesii*
- Fraser fir — *Abies fraseri* (Pursh) Poir.
- European larch — *Larix decidua* Mill.
- northern white cedar — *Thuja occidentalis* L.
- eastern hemlock — *Tsuga canadensis* (L.) Carr.

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In early June, 1 month after germination, herbicides were applied to 1-0 seedlings, which were 1 to 1½ in. tall. The 2-0 seedlings were treated early in May or June. In May of the first and second seasons mineral spirits were applied before herbicides.

The seed beds were 4 ft. by 300 ft. Herbicides were applied with a hand-held sprayer with two nozzles spraying 3-ft. swaths across the beds. The sprayer was calibrated to deliver 50 gal/A. The rates were doubled by two passes. The herbicide plots were spaced 5 ft. apart, leaving 2 ft. untreated between each. One plot in ten was left untreated. All plots except those receiving asulam or glyphosate were irrigated within 1 to 1½ hours of treatment. Plots receiving asulam or glyphosate were irrigated within 4 hours of treatment. Treatments were arranged in randomized complete blocks with three replications within each species. The herbicides and formulations used are lised in Table 1. Rates of all herbicides except glyphosate are given in terms of pounds of active ingredient per acre (lb/A). Rates of glyphosate are given in terms of pounds of acid equivalent per acre.

Weed populations varied, but common weeds were oldfield toadflax (*Linaria canadensis* (L.) Dumont), crabgrasses (*Digitaria* spp.), purslane (*Portulacca oleracea* L.), carpetweed (*Mollugo verticillata* L.), common ragweed (*Ambrosia artemisiifolia*), toadrush (*Juncus bufonius* L.), and St. Johnswort (*Hypericum perforatum* L.). Weed control was periodically evaluated by two persons using ratings on a scale of 0 to 10, with 0 as no control and 10 as 100% control. The ratings may be described as follows: 9 to 10 — excellent; 7.5 to 8.9 — good; 5.0 to 7.4 — fair: and less than 5 — poor. All weeds were removed by hand following each evaluation.

Injury to the conifers was evaluated by two persons on a scale of 0 to 10, with 0 indicating no injury and 10 indicating dead seedlings. Average injury greater than 2.0 at the end of the season was considered undesirable (20 percent or more reduction in stand or vigor). Ratings of 1.0 or less were considered insignificant.

We began large-scale trials of promising herbicides in 1971, using a tractor-mounted sprayer applying 80 gal./A. Measured sections of seedbed, usually 250 ft. long, were treated. Fifty-foot sections on one end were not treated. Injury to the seedlings was estimated, and the time required to weed in the treated and untreated beds was sometimes computed. A single crew did all weeding.

Following two seasons of herbicide application in Experiment 1, soil samples were taken from the 0 to 6 in. and 6 to 12 in. depths of certain treated and control plots for bioassay of herbicide residues. The soil was mixed, screened, divided into two equal parts, and placed in pots. In each pot we planted 30 seeds of Norway spruce, or 15 seeds of oat (*Avena sativa* L.). After 1 month in the greenhouse, injury was visually rated and the oats were weighed.

Emerged spruce seedlings were counted after 2 and 5 months, and dry weights were determined after 8 months.

In November 1974, following June treatments of 1-0 seedlings, core samples 6 in. deep were taken from selected plots of Experiment 5 for bioassay of residues in the same manner.

RESULTS

The results of the six experiments are given in Tables 2 to 8, and the results of the large-scale trials are summarized in Table 9.

Herbicides in replicated experiments

In general, herbicides applied in May to 2-0 seedlings immediately after removal of the winter cover caused no more injury than applications in June, and controlled weeds longer (Tables 2 and 3). In the case of 1-0 seedlings however, we purposely delayed herbicide applications about 1 month to allow germination to be completed. Results with individual herbicides and combinations are given below:

Alachlor was included in one experiment in 2-0 seedlings (Table 2). Although weed control was fair to excellent for 1 to 2 months with one application at 4 lb/A, injury was excessive in white pine. Norway and white spruce were not injured by alachlor, even at 8 lb/A. During the following year on the same seedlings (then 3-0), alachlor did not increase the injury to white pine, nor injure spruces.

Methazole at 3 lb/A gave fair to excellent weed control in 2-0 seedlings, but it severely injured white pine, and Norway and white spruce (Table 2).

Norea at 1.5 to 2 lb/A (Tables 2 and 3) gave fair to excellent weed control for 2 months following May application without injuring 2-0 white pine and Norway or white spruce. At 4 lb/A in May or at 2 lb/A in May plus June, however, norea injured 2-0 white pine.

S-6706 gave variable weed control and injured 2-0 seedlings of Norway spruce (Table 2).

Herbicides that caused excessive injury to 1-0 conifer seedlings included *chloramben* (Table 4), *metribuzin*, *chloroxuron*, *glyphosate* (Table 5), and *asulam* (Tables 5 and 6). Asulam slightly injured 2-0 seedlings of Douglas-fir and white pine (Table 7), but it gave only fair postemergence weed control after 3 weeks. Asulam plus DCPA caused less injury than asulam alone but gave poorer control of weeds (Tables 6, 7).

GS-13638, a triazine herbicide related to simazine, was evaluated in 2-0 seedlings of white and Norway spruce and white pine (Table 2). Seedling tolerance appeared similar to that of simazine, but in Experiment 1 weed control late in the season was less than with simazine.

Simazine was evaluated in 2-0 seedlings in three experiments (Tables 2, 3, and 7). At 1 lb/A in May, simazine consistently gave good to excellent control of broadleaved weeds and fair control of crabgrasses for about 2 months. Control was extended at 2 lb/A or with two applications at 1 lb/A without objectionable injury to white pine, Norway and white spruce, and Douglas-fir. Combinations of simazine at 1 lb/A with herbicides that control annual grasses, such as DCPA, diphenamid, napropamide, nitralin, and profluralin, generally controlled most weeds for a season without appreciable injury to the 2-0 seedlings.

Soil cores taken in December 1971 from the 0- to 6 in. depth of white pine plots treated in May and June of 1970 and 1971 with simazine at 1 lb/A or simazine at 1 lb/A plus DCPA at 9 lb/A injured oats but not Norway spruce seeded in the greenhouse. Soil cores from the 6- to 12-in. depth of these plots or from the 0- to 6-in. depth of similarly treated Norway and white spruce plots grew oats and Norway spruce seeds without injury.

Prometryn, a triazine herbicide closely related to simazine, was tested first in 1973 with 1-0 seedlings (Table 5) and then in 1974 with 1-0 (Table 6) and 2-0 seedlings (Table 7). Prometryn at 1 lb/A gave effective preemergence and postemergence control of seedling weeds and mosses for 4 to 6 weeks, and seasonal control when reapplied in July or when combined with a preemergence herbicide such as DCPA or diphenamid. Prometryn injured Douglas-fir more than white spruce, Scotch or white pine, but at 2 lb/A in June or 2 lb/A in June plus 1 lb/A in July, prometryn did not seriously injure 1-0 Douglas-fir. In 2-0 Douglas-fir and white pine, prometryn combinations with other preemergence herbicides performed as well as, or better than, simazine combinations (Table 7). Soil samples taken in November 1974 from the 0- to 6-in. depths of plots treated in June 1974 with prometryn at 2 lb/A or at 1 lb/A in combination with DCPA, diphenamid, napropamide, or oryzalin (Table 6) grew both oats and Norway spruce without injury.

Four dinitroaniline herbicides were tested: *trifluralin, nitralin, oryzalin*, and *profluralin*. They controlled annual grasses better than broadleaved weeds and had no postemergence activity. Oryzalin, even at 1 lb/A was most active of the group against weeds. Trifluralin at 4 lb/A gave only fair weed control in 1972, injured 1-0 white pine (Table 4), and was not tested further. Combining nitralin, profluralin or oryzalin with simazine or prometryn broadened their spectrum of control. Second-year seedlings of conifers tolerated nitralin and profluralin (Tables 2, 3, 7), but 1-0 seedlings sometimes were injured (Tables 4, 5, 7). During 1974, oryzalin at 1 lb/A and nitralin at 2 lb/A alone or with prometryn at 1 lb/A were effective and safe on 1-0 seedlings (Table 6), whereas profluralin at 3 lb/A was less effective and injured white pine. In 1973, however, nitralin at 2 lb/A severely injured 1-0 white spruce (Table 5), and in 1972 oryzalin at 2 lb/A excessively injured 1-0 Douglas-fir (Table 4).

Oxadiazon at 2 or 4 lb/A gave good to excellent preemergence weed control for the season but injured 1-0 or 2-0 Douglas-fir and 1-0 white spruce (Tables 4, 5, 6, 7). The injury at 2 lb/A was usually temporary, but at 4 lb/A it was excessive in one test. Injury to 1-0 white spruce and Douglas-fir and to 2-0 Douglas-fir was severe when oxadiazon at 2 lb/A was combined with prometryn at 1 lb/A (Tables 6, 7).

DCPA, *napropamide*, and *diphenamid* were included in all experiments, alone or with simazine or prometryn. When applied before weed emergence all three controlled annual grasses effectively for 2 months or more and gave variable control of broadleaved weeds. None seriously injured 1-0 Douglas-fir, white spruce, Norway spruce or white pine. Even when applied at double the normal rates or combined with simazine on 2-0 seedlings or with prometryn on 1-0 seedlings no serious injury was noted. In all cases, two applications of herbicide in one season controlled weeds longer than single applications. Soil from the upper 6 in. of plots treated four times in 2 years with napropamide at 2 lb/A contained residues that injured oats but not Norway spruce.

Large-scale trials

The large-scale trials were based on results obtained in the replicated experiments. Trials began with 2-0 and 3-0 seedlings in 1971 to 1973, and continued with 1-0 seedlings in 1974 and 1975. In 1972, 1973, and 1974, 80% of the 2-0 and 3-0 conifers were treated. In 1975, 80% of the 1-0 seedlings were also treated. The herbicides were: a) DCPA alone; b) combinations of DCPA and simazine; and c) combinations of DCPA with prometryn (Table 9).

DCPA alone was tested in a small-scale trial on 2-0 hemlocks in 1971 and on each of the 1-0 conifers in 1974. Large areas of 2-0 hemlocks were treated from 1972 to 1975. DCPA was applied at 9 lb/A on 1-0 and 2-0 hemlocks in May or early June and reapplied in July. No injury was observed, even in the 1-0 stock treated about 1 month after emergence. In addition, no injury occurred with DCPA at 9 lb/A applied in June 1974 or 1975 on 1-0 seedlings of the following species: white spruce, Norway spruce, Engelmann spruce, European larch, Japanese black pine, Scotch pine, white pine, red pine, Douglas-fir, and Fraser fir. Weed control with DCPA was similar to that in the replicated experiments, ranging from excellent where it was applied before weeds had emerged and where crabgrasses and carpetweed were the major weeds, to poor where oldfield toadflax and other broadleaved weeds were predominant. Although emerged crabgrass treated with DCPA usually was not killed, it grew on stunted roots that made it easy to pull. This decreased the weeding time and prevented the soil and conifer removal associated with weeding of untreated beds. Large-scale treatments with DCPA reduced weeding time by 30 to 80% with an average of about 50%.

Combinations of DCPA and simazine were tested primarily on 2-0 seedlings from 1971 to 1974. May applications of simazine at 1 lb/A plus DCPA at 9 lb/A were followed by mid-July to early August applications of simazine at 0.5 or 1 lb/A plus DCPA at 9 lb/A. These treatments gave excellent weed control for the season. Weeding times in treated plots were reduced 90 to 95% as compared with untreated plots 6 weeks after the May applications in 1971. Weeding times in late July or August were reduced about the same. Of the conifers treated (Table 9), only hemlocks were injured. Second-year seedlings of hemlock were injured by simazine-DCPA at 1 plus 9 lb/A in May, but 3-0 seedlings were unaffected by applications in May and July. In 1973, injury was avoided by delaying the treatment until June and reducing the rate of simazine to 0.5 lb/A. No measurements of weeding time were made, but weed control was judged better than where DCPA at 9 lb/A was applied alone.

In 1971 we also tested simazine at 0.5 lb/A plus DCPA at 4.5 lb/A on 250 ft. sections of 1-0 seedlings of Norway spruce, white pine, red pine, Japanese black pine, Douglas-fir, and European larch. These applications were delayed until July 16. No injury to these seedlings was observed and weed control was fair to good. These treatments were not considered further, however, because earlier treatments which give more effective control were desired.

Prometryn at 1 lb/A plus DCPA at 9 lb/A was applied on May 9, 1975 and repeated on June 25, 1975 over about 1.25 acres of 2-0 seedlings. These included white pine, Scotch pine, Japanese black pine, white spruce, Norway spruce, and Douglas-fir. Control was excellent with no injury observed on any conifer species. Weeding time in the treated plots was estimated at 3 man-days for the season for the 1.25 acres. Weeding times for untreated seedbeds have ranged between 30 and 40 man-days per acre in 2-0 stock at this nursery.

Large-scale trials in 1975 with the prometryn-DCPA combination on 1-0 seedlings also were successful. About 0.75 acre of 1-0 stock was treated, first on June 11, 1975, using prometryn at 1 lb/A plus DCPA at 9 lb/A and later on July 28 using prometryn alone at 1 lb/A. No injury occurred on white spruce, Norway spruce, Engelmann spruce, Douglas-fir, white pine, Scotch pine, Fraser fir, or European larch. Since hemlocks were severely injured in June, they were not treated in July. Weeding time 6 weeks after the initial treatments was reduced 80% as compared with the untreated plots. There was only a 30% reduction of weeding time in adjacent plots treated only with DCPA at 9 lb/A. Except in hemlocks, therefore, the prometryn-DCPA combination gave safe and effective weed control in 1-0 seedlings, and was more effective than DCPA alone.

DISCUSSION AND CONCLUSIONS

From the replicated experiments we learned that several herbicides could control weeds in conifer seedbeds. The large-scale trials confirmed findings in experiments with simazine, DCPA and prometryn.

Age is an important factor in sensitivity to herbicides. Several herbicides that did not injure 2-0 seedlings were marginally selective or injurious to 1-0 conifers. Because the species varied in their sensitivity, no generalizations can be made. For example, oxadiazon was more injurious to Douglas-fir than to white pine, but chloramben was more injurious to white pine than to Douglas-fir. The large-scale trials showed that the triazine herbicides (simazine and prometryn) caused more injury to hemlocks than to all other conifer species tested (Table 9). Therefore, each species and each stage of establishment must be considered in evaluating herbicides.

DCPA, diphenamid, napropamide, and prometryn were safe on 1-0 as well as 2-0 seedlings of several species. Napropamide is the newest of the four, but unlike the others, has not been widely tested in conifer seedbeds. It has proven effective in plantings of woody ornamentals (2). Napropamide may suffer from the disadvantage of being volatile and requiring irrigation soon after application, especially at high temperatures. Napropamide appears more persistent than DCPA, diphenamid, prometryn or simazine, and it could affect a cereal cover crop following repeated applications on conifer seedbeds.

Both DCPA and diphenamid appear selective on a broad range of newly-seeded conifers and control a similar spectrum of weeds. Dill and Carter (5) reported that diphenamid was safe on 1-0 loblolly and slash pines, and McDonald, et al. (10) reported diphenamid and DCPA were safe on 1-0 seedlings of lodgepole pine, ponderosa pine, Engelmann spruce, western larch, grand fir and Douglas-fir. They chose diphenamid over DCPA because weed control was more consistent. We chose DCPA over diphenamid for large-scale trials because DCPA generally was less toxic to woody plants, was less soluble in water and resisted leaching, and persisted less in the soil. We also found that DCPA was less injurious to deciduous seedlings in this nursery than other herbicides tested (3). Although either DCPA or diphenamid seem satisfactory for conifer seedbeds, our results clearly show that broad-spectrum weed control is obtained by combining either with prometryn on 1-0 stock or simazine on 2-0 stock whenever species tolerance allows.

Prometryn and simazine are closely related, but prometryn is apparently safer than simazine in newly seeded conifers, and it has greater postemergence activity, which reduces the need for mineral spirits. In extensive tests in forest nurseries in the Southeast, Dill and Carter (5) reported "prometryn at 2 lb/A gave the most consistent results of any herbicide tested", with injury to loblolly pine (*P. elliottii*) and slash pine (*P. taeda* L.) at only one of 12 locations. Four pounds per acre applied within 48 hours of seeding injured seedlings at only two of the 12 locations. Lyle, Crowley and Carter (8) reported that prometryn at 1 lb/A plus diphenamid at 4 lb/A was effective at most locations in the Southeast. They found that applications after pine emergence were safer than preemergence applications. Prometryn injured loblolly pine seedlings on loamy sand soils with low organic matter and heavy rainfall.

Although we found at least two applications of prometryn at 1 or 2 lb/A were required for seasonal control of weeds, single applications of prometryn at 1 lb/A with herbicides such as DCPA, diphenamid or napropamide controlled weeds longer than prometryn alone. In the large-scale trials one early application of prometryn at 1 lb/A plus DCPA at 9 lb/A followed by prometryn alone at 1 lb/A about 6 weeks later gave excellent control of weeds for the season. Based on our results (Table 6), prometryn does not seem hazardous to conifer seedings that may follow in rotation.

During the first two years both simazine and prometryn injured hemlocks. However, 2-0 seedlings of hemlock tolerated simazine at 0.5 lb/A plus DCPA at 9 lb/A in June, and 3-0 seedlings tolerated simazine at 1 lb/A plus DCPA at 9 lb/A twice during the season. Although newly-seeded hemlocks tolerated DCPA, further investigations are needed to find more effective or supplementary treatments for this crop.

The large-scale trials with simazine plus DCPA on 2-0 seedlings and with prometryn plus DCPA on 1-0 and 2-0 seedlings markedly reduced weeding and thereby the costs of producing conifer seedlings.

The rates of application of herbicides in these tests may not apply to other soil types and climatic conditions. Organic matter, clay content, soil temperatures and rainfall can affect herbicide selectivity.

Several of the herbicides that we tested are registered for use on transplanted or established conifers but none are registered for use in conifer seedbeds.

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Table 1. Herbicides and formulations tested in conifer seedbeds.

Common name	*Chemical name*	*Trade name*	*Formulation*
alachlor	2-chloro-2′,6′-diethyl-N-(methoxymethyl) acetanilide	Lasso	4 e.c.
asulam	methyl sulfanilylcarbamate	Asulox	liq. 3.34 lb/gal
chloramben	3-amino-2,5-dichlorobenzoic acid, ammonium salt	Amiben	liq. 2 lb/gal
chloroxuron	3-[p-(p-chlorophenoxy) phenyl]-1,1-dimethylurea	Tenoran	50 W
DCPA	dimethyl tetrachloroterephthalate	Dacthal	75 W
diphenamid	N,N-dimethyl-2,2-diphenylacetamide	Enide	50 W
glyphosate	N-(phosphonomethyl) glycine, isopropylamine salt	Roundup	liq. 3 lb/gal a.e.
GS-13638	2-methylthio-4-isopropylamino-6-tert-butylamino-s-triazine	—	50 W
methazole	2-(3,4-dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione	Probe	75 W
metribuzin	4-amino-6-tert-butyl-3-(methylthio)-as-triazine-5(4H) one	Sencor	50 W
napropamide	2-(α-naphthloxy)-N,N-diethylpropionamide	Devrinol	50 W
nitralin	4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline	Planavin	75 W
norea	3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea	Herban	80 W
oryzalin	3,5-dinitro-N^4,N^4-dipropylsulfanilamide	Surflan	75 W
oxadiazon	2-tert-butyl-4-(2,4-dichloro-5-isopropoxyphenol)-$\triangle^2$-1,3,4-= oxadiazolin-5-one	Ronstar	75 W
profluralin	N-(cyclopropylmethyl)-α,α,α-trifluoro-2,6-dinitro-N-propyl-p-toluidine	Tolban	4 e.c.
prometryn	2,4-bis(isopropylamino)-6-(methylthio)-s-triazine	Caparol	80 W
S-6706	4-chloro-5-(dimethylamino-2-(α,α,α-trifluoro-m-totyl)-3 (2H-pridazinone)	—	80 W
simazine	2-chloro-4,6-bis(ethylamino)-s-triazine	Princep	80 W
trifluralin	α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine	Treflan	4 e.c.

Table 2. Weed control and injury to second-year (2-0) conifer seedlings with herbicides applied on May 5 and June 10, 1970. Experiment 1.

Herbicide	*Rate, lb/A*		*Weed control*[1]				*Injury in Sept*[2]		
	May	*June*	*June All weeds*	*July Bdlf*	*July Grass*	*Sept All weeds*	*White pine*	*Norway spruce*	*White spruce*
untreated	—	—	0	0	0	0	0	0	0
simazine	1	0	9.2	9.2	6.3	5.3	0	0	0
	0	1	0	8.0	7.0	5.3	0	0.3	0
	1	1	9.2	9.5	8.6	7.9	0	0	0
	2	0	9.5	9.6	8.0	6.9	0	0.3	1.0
DCPA	9	0	8.4	6.8	9.4	6.1	0	0.7	0
	9	9	8.4	7.3	9.4	7.1	0	0.3	0
diphenamid	4	0	8.8	8.1	8.0	6.1	0	0	0.7
	4	4	8.8	8.7	9.7	7.4	1.3	0	0.3
simazine+DCPA	1+9	0	9.3	9.5	9.6	9.1	0	0.3	0
	1+9	1+9	9.3	9.6	9.8	9.9	0.3	0	0
simazine+	1+4	0	9.2	9.0	9.4	9.5	0	0	0
diphenamid	1+4	1+4	9.2	9.7	9.8	9.5	1.7	0.3	0.7
nitralin	2	0	6.1	4.3	9.4	8.0	0	0	0
	2	2	6.1	3.8	9.3	9.0	0.7	0	0
alachlor	4	0	9.3	7.5	9.0	2.0	3.3	0	0
	0	4	0	7.2	8.9	6.2	5.3	0	0
	4	4	9.3	9.3	9.9	6.5	6.0	0.7	0
	8	0	9.0	9.0	9.7	5.0	4.3	0	0
norea	2	0	9.0	7.6	5.8	3.6	0	0	0
	0	2	0	5.7	8.8	6.2	1.0	0	0.3
	2	2	9.0	8.6	9.2	8.8	2.7	0	0.3
	4	0	9.5	9.2	5.8	4.8	2.7	0	0.3
S-6706	2	0	6.1	3.4	9.1	7.1	0.3	2.7	0.3
	0	2	0	4.3	7.9	6.7	0.3	0	0
	2	2	6.1	4.5	9.5	7.7	1.3	3.3	0
	4	0	8.5	5.8	9.4	7.2	2.0	3.7	1.0
napropamide	2	0	8.5	6.7	9.2	5.5	0.7	0	0
	0	2	0	7.3	6.7	7.6	0.3	0	0
	2	2	8.5	8.5	9.6	7.3	0.3	0	0
	4	0	9.2	8.6	9.7	6.9	1.0	1.0	0
GS-13638	2	0	8.4	7.1	5.2	2.9	0	0	0
	0	2	0	8.4	7.9	5.6	0	0	0
	2	2	8.4	8.8	7.9	5.8	0	0	0
	4	0	8.9	8.4	5.9	5.9	0	0.3	0
methazole	3	0	9.4	9.4	8.5	7.7	6.7	2.3	1.0
	0	3	0	9.7	9.8	9.4	9.8	9.3	7.3
	3	3	9.4	9.9	9.9	9.9	10.0	9.5	7.7
	6	0	9.6	9.9	9.7	9.9	9.4	4.0	3.3

[1] 0 = no control, 10 = 100 percent control of weeds, averaged for three seedling species. Weeds in June included oldfield toadflax, toadrush, horseweed, carpetweed and crabgrass. In July oldfield toadflax comprised about 60%, crabgrasses 30%, & purslane, horseweed, carpetweed & ragweed comprised the rest. In Sept. most of the above weeds were present, but none dominated in control plots. Plots were handweeded before the May application, on 6/10 before retreatment and on 7/17 after the July evaluation.

[2] 0 = no injury; 10 = all plants dead.

Table 3. Weed control and injury to second-year (2-0) seedlings of white pine with herbicides applied on May 11 and June 17, 1971. Experiment 2.

Herbicide	*Rate, lb/A*		*Weed control*[1]		*Injury*[2]	
	May	*June*	*June 17*	*July 27*	*June 17*	*July 27*
check	—	—	0	0.3	0	0
simazine	1	0	9.6	9.7	0	0
	0	1	0	7.5	0	0
	1	1	9.6	9.8	0	0
	2	0	10.0	10.0	0	0
DCPA	9	0	9.3	7.7	0	0
	0	9	0	0	0	0
	9	9	9.3	8.0	0	0
	18	0	9.0	9.0	0	0
diphenamid	4	0	9.3	9.5	0	0
	0	4	0	3.0	0	0
	4	4	9.3	9.8	0	0
	8	0	9.3	9.2	0	0
nitralin	2	0	8.1	3.0	0	0
	0	2	0	5.3	0	0
	2	2	8.1	3.3	0	0
	4	0	9.1	6.3	0	0
napropamide	3	0	9.5	8.7	0	0
	0	3	0	5.1	0	0
	3	3	9.5	9.5	0	0
	6	0	9.8	9.2	0	0
simazine+DCPA	1+9	0	9.8	9.8	0	0
	1+9	1+9	9.8	10.0	0	0
simazine+diphenamid	1+4	0	9.9	10.0	0	0
	1+4	1+4	9.9	9.5	0	0.3
simazine+nitralin	1+2	0	9.5	9.3	0.3	0
	1+2	1+2	9.5	9.7	0	0
simazine+napropamide	1+3	0	9.8	9.8	0	0
	1+3	1+3	9.8	10.0	0	0
GS-13638	3	0	9.3	9.0	0	0
	0	3	0	9.5	0	0
	3	3	9.3	9.8	0	0
	6	0	9.8	10.0	0.3	0
norea	1.5	0	9.1	7.3	0.3	0
	0	1.5	0	5.0	0	0
	1.5	1.5	9.1	8.3	0	0.3
	3	0	9.3	7.0	0.6	0.7

[1] The predominant weed in June and July was oldfield toadflax, but carpetweed, horseweed, purslane, and crabgrasses also were present in untreated plots. The plots were handweeded on June 17 before retreatment. O = no control, 10 = 100% control.

[2] 0 = no injury, 10 = all plants dead.

Table 4. Weed control and injury to first-year seedlings (1-0) of white pine and Douglas-fir with herbicides applied June 10, 1972. Experiment 3.

				Injury[2]				
	Rate	*Weed control*[1]		*White pine*			*Douglas fir*	
Herbicide	*lb/A*	*July 10*	*Aug 8*	*July*	*Aug*	*Sept*	*July*	*Aug*
untreated	—	0	0	0	0	0	0	0
DCPA	9	4.0	6.8	0	0	0	0	0.3
	18	4.2	7.8	0	0.3	0	0	0.7
napropamide	2	8.1	6.4	0	0	0	0	0.7
	4	9.3	8.4	0	0	0	0	1.0
trifluralin	2	6.9	4.7	0	0	0.5	0	0.3
	4	7.8	5.5	0.3	1.7	2.0	0	0.3
nitralin	2	4.7	8.7	0	0	0	0	1.3
	4	6.8	9.3	0	0.3	0.7	0	3.0
oryzalin	2	8.4	8.9	0	0.7	0.7	1.7	2.7
	4	9.0	9.3	1.3	3.8	4.3	0.7	4.3
profluralin	2	7.3	5.3	0	0.7	1.0	0	0
	4	8.3	7.2	2.0	2.0	2.3	0.7	0.3
diphenamid	4	8.9	6.7	0	0.7	1.3	1.3	0.7
	8	9.3	8.8	0	0	0.7	0.7	1.0
chloramben	4	9.4	4.6	3.3	1.3	1.7	1.7	0.3
	8	10.0	6.0	4.3	4.7	4.0	2.3	3.7
oxadiazon	2	8.9	7.9	0.3	0	0.3	2.0	1.3
	4	9.5	9.2	1.3	1.0	1.3	2.3	1.0

[1] 0 = no control, 10 = 100% control of weeds.

Plots were handweeded before herbicide application on June 10 and following evaluation on July 10.

[2] 0 = no injury, 10 = all plants dead.

Table 5. Weed control and injury to first-year (1-0) conifer seedlings with herbicides applied June 8 and July 17, 1973 preemergence or postemergence to weed growth. Experiment 4.

			Weed control[1]			*Injury*[2]					
	Rate, lb/A		*July 17*		*Aug 23*	*Douglas-fir*		*White spruce*		*White pine*	
Herbicide	*June*	*July*	*Bdlf*	*Grass*	*All weeds*	*July*	*Aug*	*July*	*Aug*	*July*	*Aug*
untreated	—	—	0	0	0	0	0	0	0	0	0
Preemergence treatments											
DCPA	9	0	5.3	8.8	7.8	0	0.3	0	0	0	0
	18	0	6.5	9.2	6.8	0	1.3	0	0.3	0	0
	9	9	6.7	9.8	8.8	0	0.7	0	0	0	0
	18	9	7.5	10.0	9.3	0	1.3	0	0	0	0.3
napropamide	2	0	7.8	9.5	3.7	0.3	0	0.3	0.3	0	0
	4	0	9.1	9.3	4.1	0	0	0.3	0.7	0	1.0
	2	2	7.8	9.7	4.6	0	0	0.3	0	0	0
	4	2	9.1	9.9	5.5	0.3	0.3	0.3	0.3	0	0
diphenamid	4	0	8.3	9.0	4.7	0	0	0	0	0	0.7
	8	0	9.2	9.8	5.8	0	0.3	0.3	0.7	0	0.3
	4	4	8.6	9.6	7.0	0	0	0	0	0	0.3
	8	4	9.3	9.9	6.5	0.3	1.0	0	0	0	0.3
oxadiazon	2	0	8.8	9.5	8.6	1.0	1.3	1.0	0.7	0.3	0
	4	0	9.1	9.5	9.0	3.7	3.3	1.3	0.7	0.3	0
	2	2	8.7	9.8	8.9	1.3	2.0	1.3	1.7	0.3	0.3
	4	2	9.2	9.9	8.9	4.3	3.3	1.7	2.0	0.3	0.7
nitralin	2	0	6.7	9.8	7.7	0	0.7	0	5.3	0	0
	4	0	6.7	9.4	8.4	0	3.3	0	6.0	0	0.3
	2	2	6.8	10.0	8.8	0.3	0.7	0	3.3	0	0.3
	4	2	8.0	9.9	8.9	0	3.0	0.3	5.3	0	0.7
prometryn	1	0	8.6	9.0	3.2	0.7	0.3	0	1.0	0	0
	2	0	9.2	9.8	6.1	2.0	1.3	0	1.0	0	0.7
Postemergence treatments											
prometryn	1	1	8.3	9.6	9.5	0.7	0.3	0	0.7	0	0.3
	2	1	8.9	9.9	9.7	1.3	1.7	0.7	1.3	0	1.3
metribuzin	0.5	0	9.8	9.7	6.2	7.8	7.3	9.5	9.7	6.7	6.8
	1	0	10.0	10.0	9.2	9.0	9.5	10.0	10.0	6.8	7.7
chloroxuron	3	0	8.6	9.4	2.0	5.2	5.5	5.8	7.7	0.3	0.3
	6	0	9.0	9.8	5.0	9.3	9.8	9.3	10.0	3.0	2.0
glyphosate	0.4	0.5	3.5	4.9	9.7	1.3	5.7	0	1.0	0	1.7
	0.8	0.5	3.9	4.6	9.6	5.3	8.3	0	2.7	2.6	3.3
	0	0.5	0	0	9.7	0	3.0	0	1.0	—	—
asulam	0	4	0	0	4.5	0	3.3	0	0	0	0

[1] The preemergence plots were handweeded before herbicide application on June 8 and July 17 after evaluation. 0 = no control, 10 = 100 percent control of weeds.

[2] 0 = no injury, 10 = all plants dead.

Table 6. Weed control and injury to first-year (1-0) conifer seedlings with herbicides applied on June 5, 1974. Experiment 5.[1]

		Weed control			*Injury*[2]			
		June 27		*Aug 27*				
Herbicide	*Rate lb/A*	*crabgrass*	*carpetweed & toadflax*	*all weeds*	*White pine*	*Scotch pine*	*Douglas fir*	*White spruce*
untreated		0	0	0.6	0	0.1	0.2	0.4
DCPA	10	7.5	8.2	5.4	0	0.2	0	0
napropamide	3*	8.9	8.4	1.8	0	0	0.6	0
prometryn	1	9.2	9.3	3.6	0.2	0	0	0
	2*	9.7	9.5	8.0	0	0	0.9	0
diphenamid	4*	8.0	8.8	2.9	0	0	0	0
oxadiazon	2*	8.4	9.2	8.5	0.2	0.2	1.4	1.4
profluralin	3*	9.6	9.2	5.3	1.2	0.6	0.7	0.1
nitralin	2*	8.7	6.7	8.7	0.1	0	0.2	0.9
oryzalin	1*	9.0	8.7	8.4	0.2	0	0.8	0.9
DCPA+prometryn	10+1*	9.7	9.4	8.8	0.1	0	0.5	0.1
napropamide+prometryn	3+1*	9.8	9.6	8.3	0.1	0	0.9	0.2
diphenamid+prometryn	4+1*	10.0	9.7	9.2	0	0	0.8	0.4
profluralin+prometryn	3+1	10.0	9.5	7.6	1.2	0.9	0.8	0.2
nitralin+prometryn	2+1*	9.7	9.3	9.0	0.1	0	1.5	0.2
oryzalin+prometryn	1+1*	9.8	9.3	8.1	0	0	0.9	0.2
oxadiazon+prometryn	2+1	9.8	9.7	9.4	1.2	0.8	4.0	3.2
asulam	3	10.0	4.2	4.3	2.7	1.1	3.2	3.0
asulam+DCPA	3+10	7.6	7.9	2.3	0.3	0	0.2	0.3

[1] The plots were handweeded on June 5 before treatment and on June 27 and Aug 14 following evaluation. 0 = no control, 10 = 100 percent control of weeds.

[2] Average of injury ratings in June, August and November. 0 = no injury, 10 = all plants dead.

*Soil samples taken in November from the 0 to 6 inch depth in plots receiving these treatments grew seeds of oats and Norway spruce without injury.

Table 7. Weed control and injury to second-year seedlings (2-0) of white pine and Douglas-fir with herbicides applied June 4, 1974. Experiment 6[1]

		Weed control June 27			*Injury*			
					Douglas fir		*White pine*	
Herbicide	*Rate lb/A*	*Douglas fir*	*White pine*	*Avg.*	*June 27*	*Nov 14*	*June 27*	*Nov 14*
untreated	—	0	0	0	0	0	0	0
prometryn	1	9.2	9.7	9.5	0.7	0	0.3	0
	2	9.2	9.8	9.5	1.3	0.3	0	0
DCPA+simazine	10+1	7.8	9.5	8.7	0.3	0	0	0
DCPA+prometryn	10+1	8.8	9.7	9.3	0.7	0.3	0.7	0
diphenamid+simazine	4+1	9.2	9.7	9.5	0	0	0	0.3
diphenamid+prometryn	4+1	9.2	9.7	9.5	0.3	0	0	0
napropamide+simazine	3+1	9.3	10.0	9.7	0.7	0	0	0
napropamide+prometryn	3+1	9.2	9.2	9.2	0.3	0	0	0
profluralin+simazine	3+1	9.0	9.5	9.3	0	0	0	0
profluralin+prometryn	3+1	9.0	9.8	9.4	1.0	0	0	0
nitralin+simazine	2+1	8.7	9.3	9.0	0	0	0	0
nitralin+prometryn	2+1	8.5	9.5	9.0	0.3	0	0	0.3
oxadiazon	2	7.3	6.2	6.8	2.7	0.7	0.3	0.3
oxadiazon+prometryn	2+1	8.7	9.0	8.9	3.3	0.7	0.3	0
oryzalin	1	4.3	4.7	4.5	0	0.3	0	0
oryzalin+prometryn	1+1	9.0	9.5	9.3	1.7	0	0	0.3
asulam	3	6.7	7.0	6.9	1.0	1.3	1.7	0
asulam+DCPA	3+10	4.7	2.7	3.7	0	0.3	0	0

[1] Emerging seedlings of weeds were present in the plots at treatment time. The plots were handweeded following the evaluation on June 27 and weed populations in the plot areas were sparse thereafter.

Table 8. Tolerance of 1-0 and 2-0 conifer seedlings to herbicides in replicated trials.[1]

Herbicide	*White pine*		*Scotch pine*	*White spruce*		*Norway spruce*	*Douglas-fir*	
	1-0	*2-0*	*1-0*	*1-0*	*2-0*	*2-0*	*1-0*	*2-0*
alachlor	—	S-4	—	—	T-8	T-8	—	—
asulam	S-3	T-3	S-3	S-3	—	—	S-3	T-3
chloramben	S-4	—	—	—	—	—	S-4	—
chloroxuron	T-3, S-6	—	—	S-3	—	—	S-3	—
DCPA	T-18	T-18	T-10	T-18	T-9+9	T-9+9	T-18	T-10
diphenamid	T-8	T-8	T-4	T-8	T-4+4	T-4+4	T-8	T-4
glyphosate	T-.4 S-.8	—	—	T-.8 S-.8+.5	—	—	S-.4	—
GS-13638	—	T-6	—	—	T-4	T-4	—	—
methazole	—	S-3	—	—	S-3	S-3	—	—
metribuzin	S-.5	—		S-.5	—	—	S-.5	—
napropamide	T-4	T-6	T-3	T-4	T-4	T-4	T-4	T-3
nitralin	T-4	T-4	T-2	S-T-2	T-2+2	T-2+2	T-2, S-4	T-2
norea	—	T-2, S-2+2	—	—	T-4	T-4	—	—
oryzalin	T-2, S-4	T-1	T-1	T-1	—	—	T-1, S-2	T-1
oxadiazon	T-2	T-2	T-2	S-2	—	—	S-2	S-2
profluralin	S-3	T-3	T-3	T-3	—	—	T-3	T-3
prometryn	T-2+1	T-2	T-2	T-2+1	—	—	T-2+1	T-2
S-6706	—	T-2, S-4	—	—	T-4	S-2	—	—
simazine	—	T-2	—	S-1	T-2	T-2	—	T-1
trifluralin	T-2, S-4	—	—	—	—	—	T-4	—

[1] S — susceptible — injured by treatments at indicated dosage in lb/A.
T — tolerant, slight or no injury at indicated dosage in lb/A.
S-T — variable responses in different tests.

Table 9. Tolerance of first-year (1-0); second-year (2-0) or third-year (3-0) conifers treated with DCPA alone or in combination with simazine or prometryn in large-scale trials.

Species	*Age*	*DCPA 9 lb/A*	*Simazine 1 lb/A+ DCPA 9 lb/A*	*Prometryn 1 lb/A +DCPA 9 lb/A*
White spruce	1-0	T	—	T
	2-0	T	T	T
Norway spruce	1-0	T	t	T
	2-0	T	T	T
Englemann spruce	1-0	T	—	T
White pine	1-0	T	t	T
	2-0	T	T	T
Scotch pine	1-0	T	—	T
	2-0	T	T	T
Japanese black pine	1-0	T	t	T
	2-0	T	T	T
Red pine	1-0	T	t	T
	2-0	T	T	T
Douglas-fir	1-0	T	t	T
	2-0	T	T	T
Fraser fir	1-0	T	—	T
	2-0	T	T	T
European larch	1-0	T	t	T
	2-0	T	T	T
No. White cedar	2-0	T	T	—
Hemlock	1-0	T	—	S
	2-0	T	S*	—
	3-0	T	T	—

T = tolerant, no injury from 2 applications in one season.
S = susceptible — injured or killed by one application in June (4-5 weeks after emergence of 1-0 seedlings).
t = not injured by one application 10 weeks after emergence at half rates (simazine .5 lb/A + DCPA 4.5 lb/A).
* — not injured by one application in June at half rate of simazine (.5 lb/A) plus DCPA 9 lb/A.