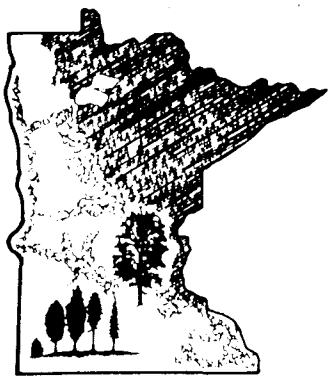

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GLYPHOSATE AND 2,4-D APPLICATION OVER RED PINE SEEDLINGS WITH HAND-HELD EQUIPMENT

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ABSTRACT

Glyphosate is a 1% and a 2% solution and 2,4-D in a 1% solution were hand-sprayed directly over 6-month-old containerized Pinus resinosa seedlings outplanted for two seasons. Glyphosate controlled a broader range of important vegetative competitors than 2,4-D, but also resulted in substantial damage to many of the pine.

Background

Red pine (Pinus resinosa, Ait.) is the most widely planted species in Minnesota for reforestation. The species has relatively slow juvenile growth in comparison to competing vegetation. Therefore a primary problem in establishment of red pine is the control of competing woody species. A number of lesser herbs and grasses also compete and may result in early suppression.

The usual method of controlling undesirable competing vegetation is with herbicides particularly formulations of the phenoxy herbicides, 2,4-D and 2,4-DP. These herbicides are selective, killing some herbaceous and woody angiosperms but not injuring the conifers targeted for release. Unfortunately, they are ineffective against grasses and some angiosperm competitors.

Hansen and Sucoff (1978) in their survey, reported that over 50 percent of the herbicide application in Minnesota was by helicopter with less than 10 percent being done by hand sprayers such as used in this study. This percentage could conceivably increase in the future as more selective spraying is done. The survey indicated that the cost of selective hand spraying was higher than aerial broadcast but much less than that for manual or mechanical release.

Herbicide Description

The phenoxy herbicides are well known, but glyphosate (N-[phosphonomethyl] glycine) marketed as Roundup® /1 has only recently been labeled by the EPA for use in site preparation and release of conifers. It is a broad spectrum herbicide that affects woody vegetation as well as grasses and herbs. The herbicide is water soluble; the absence of residual effect makes it especially useful for site preparation for reforestation since areas can be planted soon after treatment. Glyphosate has an acute oral LD_{50}, about one tenth that of 2,4-D (Weed Science Society of America, 1979). The herbicide is relatively expensive but this may be offset by low volume treatments and long-term control. Glyphosate is a systemic herbicide entering plants through the foliage and translocating to other portions of the plant, including roots. For release of conifers, glyphosate should be sprayed as late as possible in the growing season, after bud set on the conifers and before leaf fall of the target species.

There have been a number of studies conducted with glyphosate. Mann (1979) found it to be highly effective when injected into unwanted hardwoods in the southern U.S. Encouraging results were reported by Newton (1977) for release and site preparation in western Oregon. Sutton (1978) reported good control of trembling aspen, white birch, beaked hazel, and mountain maple. He also reported some damage to newly planted 3-0 white spruce and suggested shielding the conifers from the herbicide treatment. He stressed the need for newly flushed growth of conifers such as white spruce and red pine to be hardened-off before release treatment with glyphosate.

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Study Description

The objective of this study was to test the effectiveness of glyphosate and 2,4-D as release sprays for red pine seedlings using hand-held equipment. An assessment of damage to the red pine was made in addition to an evaluation of the effectiveness of the herbicide treatments on the selected target species.

The study area was a jack pine Pinus banksiana cutover on Omega loamy sand soil located in northeastern Minnesota on the University of Minnesota Cloquet Forestry Center. The jack pine stand had been clearcut under the tree-length system in fall, 1977. The slash was burned in April, 1978. In June, 1978 the area was planted with 6-month-old containerized red pine seedlings grown in styroblock "2" (2.5 cubic inch plug) containers.

Three herbicide treatments were used. Glyphosate was applied in a 1% solution (4 oz/3 gal H_2O) and a 2% solution (8 oz/3 gal H_2O) as recommended on the EPA label for hand-held equipment and spot spraying. The third treatment was 2,4-D (Esteron $99^{/2}$ concentrate) at the rate of 1% (4 oz/3 gal H_2O) as recommended for spot treatment.

The herbicides were applied on August 15, 1979 with a hand operated, two-gallon pump type sprayer. The operator applied the herbicide mix to a two-foot radius using the seedling as the plot center. Application was on a spray-to-wet basis but not to the point of runoff. This is as indicated on the EPA label. Temperature was about 65°F at the time of spraying with no wind. Buds were obvious on all seedlings at the time of application.

Four blocks each of three rows were selected for the study. Each row in a block received a different herbicide treatment and there were 25 seedlings per row for a total of 100 seedlings per treatment. These seedlings were about 7 feet apart within and between rows. Each seedling was classified into one of three categories:

1. Open - no vegetative competition that would shield the seedlings from the spray.
2. Partial - seedlings overtopped with enough vegetative competition to partially shield them.
3. Full - seedlings completely overtopped by competing vegetation that served as a shield.

Pine seedling height and 1979 growth were measured on the trees prior to the herbicide application.

Seedling Category	Average 1979 Growth (in.)	Average Total Height (in.)
Open	8.8	12.2
Partial cover by competition	6.2	9.5
Full cover by competition	4.8	7.8

Total height and 1979 growth were significantly ($P = 0.05$) different for each seedling category indicating a need for release as the vegetative competition was already suppressing growth.

A species list was made of the competitors within 2 feet of each seedling (Table 1). This inventory was done immediately before spraying and again at the height of vegetative activity the growing season following spraying (July 15, 1980).

An assessment was made of each pine seedling as to degree of damage resulting from the herbicide treatment (Table 2). This was done 30 days after application and again the following growing season on July 15.

Results and Interpretation

The three major woody competitors on these plots were beaked hazel (Corylus cornuta Marsh.), trembling aspen (Populus tremuloides Michx.), and pin cherry (Prunus pennsylvanica L.f.). The number of plots with these species was reasonably consistent between the three selected herbicide treatments. By July 15, 1980 these species had been eliminated from 95-100 percent of the plots under all of the herbicide treatments except aspen on the 2,4-D treated plots (Table 1). However, even on the 2,4-D plots that still had aspen present, kill was sufficient to consider the release successful.

Honeysuckle (Lonicera spp.) was initially present on about 60 percent of the plots under all treatments. The 2,4-D and both rates of glyphosate sufficiently killed honeysuckle. Blackberry and raspberry (Rubus spp.) are often serious competitors and difficult to kill. Only the 2% glyphosate solution effectively reduced the number of plots where these species were present (Table 1). However, both the glyphosate rates killed most of the older Rubus stems; the stems on July 15 had primarily emerged in 1980. The 2,4-D plots had both adults and current season shoots as indicated by the 28 percent increase. The presence of bracken fern (Pteridium aquilinum (L.) Kuhn.) was reduced by both glyphosate treatments but not by 2,4-D. Glyphosate has been reported as being effective in bracken fern control (Anon, 1978).

On this particular site, sweetfern (Comptonia peregrina Coult.) is an important competitor present on about 95 percent of the plots. Poor control was achieved with 2,4-D, but both glyphosate applications reduced this species substantially. Another important competitor was grass. The 1% and 2% glyphosate solutions reduced the number of plots with grass by 71% and 95%, respectively. Under the 2,4-D treatment, the number of plots having grass increased by 13%. This frequently happens on sites where death of the woody vegetation releases the grass from competition.

Both glyphosate concentrations resulted in considerable damage to red pine (Table 2). Much of the mortality and damage to the seedlings on the glyphosate plots was not evident after 30 days, on September 15, 1979, but was seen the following growing season during the July 15 inventory. Shielding by competing vegetation did not decrease damage to the pine. The highest pine mortality was on those plots with full cover. This is likely a result of more spray being applied to those plots since spraying was continued until all vegetation was wet. On the 2,4-D plots many of the seedlings assessed after 30 days as being damaged recovered fully by July 15, 1980. The 2,4-D application killed no trees and on the plots where the seedling was shielded there was no evidence of herbicide damage by the first growing season after application.

It should be noted that the six-month-old containerized seedlings had been in the field since June, 1978 with the spray applied in August, 1979. There is little information available on the effect of herbicides on container plantings of this age. This data indicated that 2,4-D does not injure red pine containerized seedlings. But it is evident that the use of glyphosate on seedlings of this age can result in considerable mortality and damage. The glyphosate EPA label indicates the chemical can be used where conifers have been established for more than a year. This experiment suggests that age and condition of the seedling when planted in the field should also be major considerations.

Conclusions

All three herbicide treatments effectively reduced woody shrub competition to successfully release red pine seedlings. On sites where grass was a suppression problem, glyphosate was more effective. However, glyphosate hand-sprayed in mid-August on containerized red pine planted in June of the previous year resulted in mortality and damage to the pine. Perhaps a later spraying would have caused less damage. As the label indicates, and as other researchers have pointed out, release spraying with glyphosate should be delayed as late in the season as possible to avoid seedling damage. Additional trials should precede widespread application of glyphosate on young seedlings such as the containerized stock used in this study.

1/ Registered Trademark of Monsanto Agricultural Products Company, St. Louis, MO.

2/ Registered Trademark of Dow Chemical Company.

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The glyphosate used in this study was contributed by Monsanto Company.

The use of trade names does not constitute their endorsement or criticism by the University of Minnesota.

Table 1. Species presence (in percent) on sample plots before and after herbicide application and percent reduction. Each plot is a circle of 2 foot radius with pine seedling in center.

Vegetative Species	Glyphosate (1%)			Glyphosate (2%)			2,4-D (1%)		
	Before	After	% Reduction	Before	After	% Reduction	Before	After	% Reduction
Corylus cornuta---------	70	3	95	69	0	100	70	0	100
Populus tremuloides-----	27	1	96	25	0	100	23	6	74
Prunus pennsylvanica----	47	2	96	35	0	100	40	2	95
Acer rubrum-------------	8	0	100	5	0	100	3	1	67
Betula papyrifera-------	4	0	100	3	0	100	7	0	100
Lonicera spp.-----------	60	9	85	58	3	95	61	17	72
Rubus spp.--------------	19	19	0	25	10	60	25	32	+28
Amelanchier spp.--------	7	1	86	6	0	100	5	0	100
Comptonia peregrina-----	21	5	76	30	1	97	29	3	90
Pteridium aquilinum-----	97	30	69	95	21	78	95	93	2
Miscellaneous grasses---	76	22	71	73	4	95	71	80	+13

Table 2. Percent of red pine seedlings damaged by herbicide observed 30 days after application and the first growing season after application.

Degree of Herbicide Damage[2]	Glyphosate (1%)		Glyphosate (2%)		2,4-D	
	30 days	1 year	30 days	1 year	30 days	1 year
Seedling Exposure[1]	(%)	(%)	(%)	(%)	(%)	(%)
Open						
Dead	3	6	18	50	0	0
Affected	36	15	50	29	25	8
No Affect	61	79	32	21	75	92
Partial Cover						
Dead	0	4	21	71	0	0
Affected	54	38	79	25	44	6
No Affect	46	58	0	4	56	94
Full Cover						
Dead	0	0	17	100	0	0
Affected	78	44	83	0	33	0
No Affect	22	56	0	0	67	100

1/ Open = no vegetation that would shield the seedling from herbicide spray.
Partial = the seedling was overtopped by adjacent vegetation, but not fully shielded.
Full = the seedling was fully shielded by overtopping vegetation.

2/ Dead = brown needles, bud damaged.
Affected = brown needles, yellowing, no apparent bud damage.
No Affect = no visible symptoms of damage.

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