Oxyfluorfen Shows Promise in Lodgepole Pine Seedbeds

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The herbicide oxyfluorfen was applied at 0.75 and 1.50 pounds per acre to lodgepole pine (Pinus contorta *Dougl. ex Loud) nursery beds. First-year treatments reduced seedling heights. Second-year applications had little effect on seedling heights or densities. Oxyfluorfen reduced weeding times by 76%.* Tree Planters' Notes 38(2):03-9 ; 1988.

Oxyfluorfen [2-chloro1-(3-ethoxy-4-nitrophenoxy)-4(trifluoro-methyl)benzene] is a broad-spectrum selective herbicide of the diphenylether group. Richardson and others (11) recommended it for use in several crops: soybeans, cotton, peanuts, wheat, rice, legumes, sugar beets, and tree and vine plantation crops.

It was used experimentally in seedbeds of southern pines beginning in 1976 and was registered by the Environmental Protection Agency in 1979 (14). Since then, southern nurserymen have used oxyfluorfen in pine seedbeds for both preemergence and postemergence treatments (15). It is effective in controlling most broadleaf weeds and many grasses found in forest nurseries (6, 7, 14, 15).

In comparisons with other diphenylether herbicides, Yih and Swithenbank (18) found that oxyfluorfen had more than 10 times greater activity than nitrofen and fluorodifen, and a broader spectrum of activity as well. This increase in activity means a significantly lower rate of chemical application and a reduced possibility of contamination in the environment.

The herbicidal activity of oxyfluorfen and other diphenylether herbicides takes place through lipid peroxidation, which damages cellular membranes, especially those of organelles (3, 6, 8, 10, 12). Light is essential in the activation process of oxyfluorfen (3, 7, 8, 9, 17, 18); in fact, darkness completely inhibits the herbicide.

Fadayomi and Warren (3) reported that oxyfluorfen is inactivated in muck soils. There is little inactivation by clays, and in data presented by South and Gjerstad (14) there is no apparent relationship between weed control or phytotoxicity and percentage of organic matter in the soil.

A few studies have tested oxyfluorfen on pine seedbeds. South and Gjerstad (14) conducted pre-emergence tests at 11 southern pine nurseries. They found that application rates of 0.5 to 1.0 pounds of active ingredient per acre (0.56 to 1.12 kg/ ha) provided good weed control without damage to loblolly (*Pinus taeda* L.), slash (*Pinus elliottii* Engelm.), shortleaf (*Pinus echinata* Mill.), longleaf (*Pinus palustris* Mill.), Virginia *(Pinus virginiana* Mill.), and eastern white pine (*Pinus strobus* L.). Generally, postemergence applications of 0.5 to 1.0 pounds per acre (0.56 to 1.12 kg/ha) provided 55 to 84% weed control for the remainder of the handweeding season. Again, no injury to pine seedlings was observed.

South and Mexal (15) showed that at the pre-emergence rate of 0.5 pounds per acre (0.56 kg/ha), oxyfluorfen did not significantly reduce early growth of loblolly pine seedlings, but at 1.0 pounds per acre (1.12 kg/ha) average seedling heights were significantly reduced. Neither concentration had significant effects on seedling densities by the 25th day after sowing. In growth chamber tests, a rate of 1.39 pounds per acre (1.56 kg/ha) applied before germination produced white lesions on the stems of a third of the seedlings.

Abrahamson and Burns (1) tested oxyfluorfen at four forest nurseries of the Great Plains. They found that at 0.25 pounds per acre (0.28 kg/ha) a preemergence application did not reduce weed growth. Survival of ponderosa (*Pinus ponderosa* Dougl. ex Laws.), loblolly, Austrian (*Pinus nigra* Arnold), and lodgepole (*Pinus contorta* Dougl.) pine treated with oxyfluorfen was not statistically different when compared to untreated plots.

Yih and Swithenbank (18) found oxyfluorfen close to 100%

effective in greenhouse weed control tests. The herbicide was applied at both pre-emergence and postemergence timings and at four concentrations from 0.11 pounds per acre (0.125 kg/ha) to 0.89 pounds per acre (1.0 kg/ha).

Turner and Richardson (16) applied oxyfluorfen at 0.44 pounds per acre (5.0 kg/ha) in postemergence applications to lodgepole pine seedlings in pots. They found no significant phytotoxic effects.

In tests done by Heidmann and Haase (5), oxyfluorfen at a rate of 0.5 pounds per acre (0.56 kg/ha) was effective in controlling weeds when applied after seeding. Postemergence applications of up to 1.5 pounds per acre (1.68 kg/ha) did not significantly reduce weed growth. Damage to ponderosa pine seedlings was variable using 0.5 pounds per acre (0.56 kg/ha) pre-emergence. Postemergence applications did not reduce the mean density of ponderosa pine seedlings in the nursery bed.

Schlesselman and Lange (13) demonstrated that a 3-day delay in irrigation after pre-emergence applications of oxyfluorfen can cause a reduction in the herbicide's residual effect. Further, temperature has the most pronounced effect. Applications in the hot summer months have less residual effect than in the fall, when temperatures have cooled off.

Oxyfluorfen is an effective herbicide for controlling weeds and at much lower application rates than many other herbicides. However, further study is required before it can be used with confidence on lodgepole pine. This paper reports the results of phytotoxicity and weed control tests in lodgepole pine seedbeds at Lucky Peak Nursery near Boise, ID.

Methods

The study had two parts: 1) A phytotoxicity test to determine the effects of pre-emergence and postemergence applications of oxyfluorfen on lodgepole pine seedling survival and growth, and 2) a weed control test to find out what effect oxyfluorfen would have on the time required to hand weed nursery beds.

Phytotoxicity test. The plots were set up in a randomized complete block with six replications. Each replication contained 10 combinations of dosage and time of application plus one untreated control plot. Each plot was 3 feet (0.91 m) long with a 1-foot (0.30-m) buffer strip in between. All plots were in a single nursery bed 4 feet (1.2 m) wide. Table 1 explains the 11 treatments.

Table 1—*Concentrations and timing of the oxyfluorfen treatment*

	First year				Second year			
	April 29[a]		June 16[b]		April 17		June 26	
	0.75 lb/acre	1.50 lb/acre	0.75 lb/acre	1.50 lb/acre	0.75 lb/acre	1.50 lb/acre	0.75 lb/acre	1.50 lb/acre
Phytotoxicity								
1 × PS (1)	•							
1 × PS (1 + 2)	•				•		•	
2 × PS (1)		•						
2 × PS (1 + 2)		•				•		•
PS + PG (1)	•		•					
PS + PG (1 + 2)	•		•		•		•	
1 × PG (1)			•		A		A	
1 × PG (1 + 2)			•		•		•	
2 × PG (1)				•				
2 × PG (1 + 2)				•		•		•
No treatment								
Weed control								
1 × PS	•				•			
1 × PS + 1 × PG	•		•		•		•	
No treatment								

[a]Oxyfluorfen applied 1 day after sowing.
[b]Oxyfluorfen applied 48 days after sowing.
PS = postseeding, PG = postgermination.

We applied oxyfluorfen in a 4.5-foot (1.4-m) swath using an AZ small-plot pressurized sprayer. The emulsifiable concentrated herbicide was diluted in a water carrier at a volume equivalent to 85 gallons per acre (127 liters/ha) or 100 ml per 3-foot (0.91-m) plot. Preemergence treatments were applied within 2 days after sowing (April 29, 1983). Postemergence sprays were applied 4 to 5 weeks after seedling emergence (June 16, 1983). We made second-year applications on April 17 and June 26, 1984. Application rates were 0.75 pounds of active ingredient (a.i.) per acre (0.84 kg/ha) (1 x concentration) and 1.5 pounds a.i. per acre (1.69 kg/ha) (2 x concentration).

Nursery personnel conducted all normal cultural activities as scheduled except use of herbicides and weeding.

To compare each treatment with the control plot we used a herbicidal damage rating scale (2) at the end of the first and second growing seasons. At the same time, we counted the number of live seedlings and measured average heights in three 1-foot (0.30-m) sample rows in every plot. At the end of the second growing season we lifted the trees in all three sample rows from which we randomly selected 10 trees to measure dry weights of shoots and roots. Data were analyzed using analysis of variance and single degree of freedom comparison of means (4).

Weed control test. In a seedbed adjacent to the phytotoxicity test we established treatment plots for the weed control test in a randomized complete block with three replications. Within a block, we put two treatments and one control plot. Each plot was 20 feet (6.1 m) long, and plots were separated by a 1-foot (0.30-m) buffer strip. The application timing and herbicide dosage are explained in table 1. Spray methods and application dates and rates were the same as for the phytotoxicity tests.

Table 2—*Comparison of treatment means with control plot means for second-year phytotoxicity data for oxyfluorfen on lodgepole pine*

Treatment	Mean tree height (cm)	Mean No. of seedlings/ ft of row	Mean damage rating[a]	Mean top dry weight (g)	Mean root dry weight (g)
1 × PS (1)	12.73 **	8.48NS	7.50**	5.60 NS	2.76 NS
1 × PS (1 + 2)	11.62 **	8.78NS	7.33**	5.31 NS	2.54 NS
2 × PS (1)	10.83 **	5.60**	5.67**	5.27 NS	3.11 NS
2 × PS (1 + 2)	10.43 **	5.07**	5.50**	5.41 NS	3.01 NS
1 × PG (1)	12.73 **	15.40*	9.33NS	4.34 NS	2.16 NS
1 × PG (1 + 2)	12.2 **	12.73NS	9.33NS	4.48 NS	2.40 NS
2 × PG (1)	11.77 **	12.38NS	9.17NS	4.46 NS	2.31 NS
2 × PG (1 + 2)	11.78 **	10.57NS	8.83*	4.31 NS	2.35 NS
PS + PG (1)	10.93 **	8.8 NS	6.67**	4.99 NS	2.56 NS
PS + PG (1 + 2)	11.00 **	6.93*	7.00**	5.01 NS	2.81 NS
No treatment	14.83	11.17	10.00	5.50	2.64
Total average	11.86	9.63	7.85	4.97	2.61

* = Significantly different from the "no treatment" mean (α = 0.05) using the single degree of freedom comparison *(4)*.
** = Significantly different from the "no treatment" mean (α = 0.01) using the single degree of freedom comparison *(4)*.
NS = No significant difference from the "no treatment" mean (α = 0.05) using the single degree of freedom comparison *(4)*.
[a]Damage rating is based on "no treatment" plots and ranges from 10 (no damage) to 1 (complete mortality).

Results

Phytotoxicity tests. Damage by the 1.5 pound a.i. rate was more severe than the 0.75 pound a.i. rate (table 2). Plots sprayed with the higher concentration of herbicide after seeding showed a significant reduction in number of seedlings. Likewise, the plots sprayed at all four application times had significantly fewer trees than control plots. The postemergence plots sprayed with 0.75 pound per acre had significantly more trees. All spray treatments reduced height growth of the seedlings. The subjective damage ratings show that all postseeding treatments reduced the overall growth and survival, as did the 1.5-pound rate applied at a postemergence timing both years. None of the treatments significantly affected the mean dry weights of tops or roots.

When compared, first-year treatment means were consistent with second-year measurements given in table 2.

Weed control tests. In the weed control test (fig. 1) the plots with 0.75 pound per acre applied in April of both years took 66% less time to weed than did the control plots. The other treatment, in which the same rate was applied in April and June each year, took 76% less weeding time than the control. The differences in weeding times compared to untreated plots were statistically significant (a = 0.01). Most of the weeding time came in the second year. Even on control plots, there were few weeds the first year.

Discussion and Conclusions

Most of the phytotoxic effects of the oxyfluorfen applications took place in the first growing season. Mortality was high only on plots sprayed with the 1.5 pounds per acre concentration of herbicide immediately following seeding. Figure 2 shows how little seedling density changed for most treatments between the first and second years. Also, there is little difference in mean density between plots that

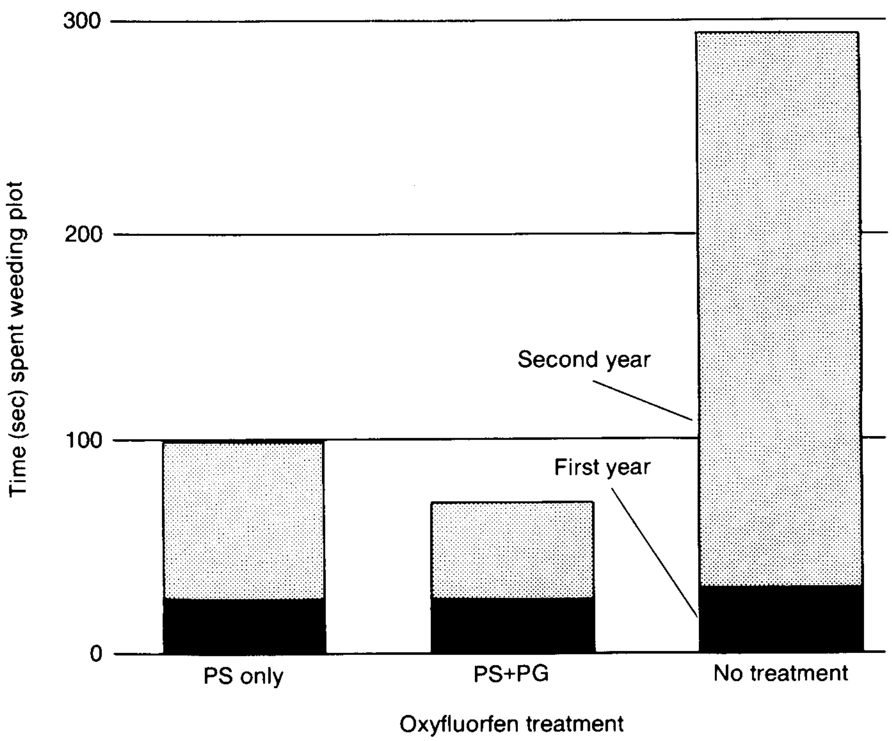

Figure 1—*Average weeding times on 30-foot test plots. The pre-emergence treatment plots were sprayed with oxyfluorfen in April of both years. The pre-emergence and postemergence plots were sprayed in April and June of both years. All applications were at 0.75 pound per acre.*

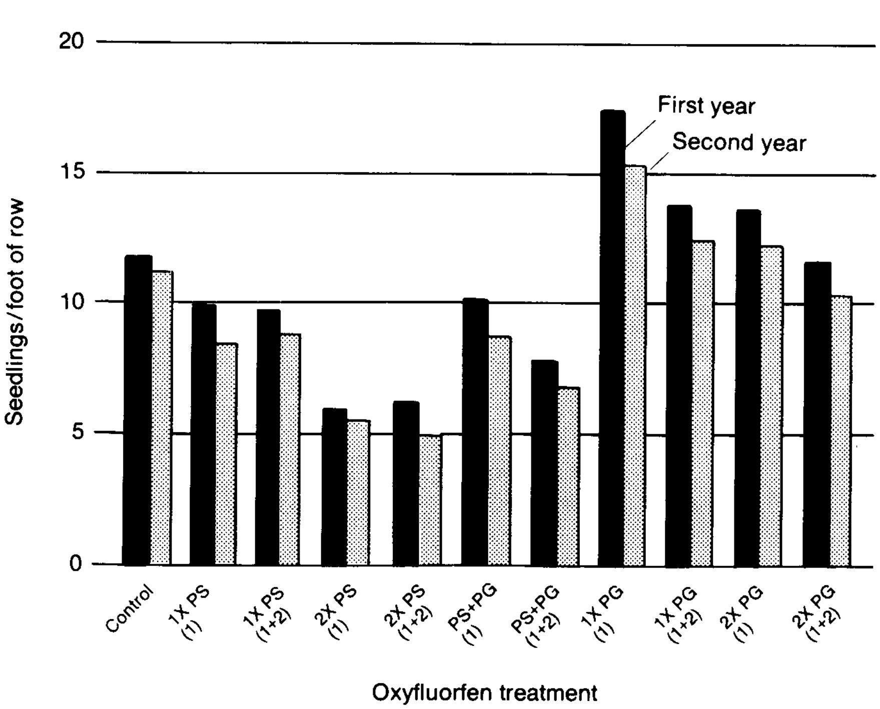

Figure 2—*Effect of oxyfluorfen treatments on density of live lodgepole pine seedlings in the nursery bed for the first and second growing seasons. Control = no treatment, 1× = 0.75 pound per acre active ingredient, 2× = 1.50 pound per acre active ingredient, PS = postseeding, PG = postgermination, 1 = first year only, 1 + 2 both first and second year. See table 1 for more information on timing of applications.*

received second-year applications and those that did not. The one exception is on the plots recorded. Again, all nursery operations except use of herbicides were conducted by nursery personnel when required.

All plots were hand weeded twice during both growing seasons, and weeding times were that had a 0.75-pound-per-acre spray all four times. They showed a slight reduction in seedling density the second year compared to the control.

The first-year postemergence treatment shows a higher mean seedling density than the control because of a much higher sowing density on one of the plots. Weed competition was not an important factor in reducing seedling density. Figure 3 compares four plot treatments as viewed from above and illustrates the reduction in seedling density from the control, to the 2 x postemergence, to the 1 x pre-emergence and postemergence, to the 2 x pre-emergence applications.

The average height of seedlings was diminished by all of the oxyfluorfen spray schedules in this study and at both concentrations. The highest average reduction in height came on plots with pre-emergence applications. The 2 x concentration of oxyfluorfen seemed to have more detrimental effects on seedling height, and again, most of the herbicide damage was done in the first growing season.

The damage ratings emphasize what has been shown in the seedling heights and plot densities. Pre-emergence sprays have the most phytotoxic effects on lodgepole pine seedlings. The herbicide treatments seem to have little effect on the dry weight of seedlings because even though control plot trees were taller, the oxyfluorfen generally reduced the density on the other plots. The low-density plots produced bushier trees with larger calipers. This increased caliper compensated for the shorter height in the dry weight measurements.

When Abrahamson and Burns (1) tested oxyfluorfen on lodgepole pine seedbeds, their results were similar. However, at

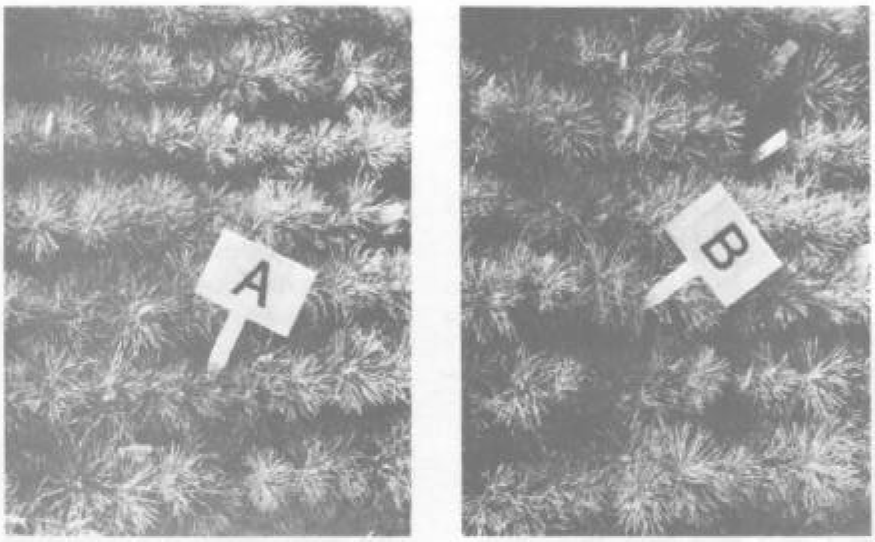

Figure 3—*Overhead view of four plots, each with a different first year oxyfluorfen treatment. None of the plots were sprayed during the second year. No treatment* **(A).** *1.5 pounds per acre postemergence* **(B).**

the reduced rate of 0.25 pound per acre, reductions in seedling heights and survivals were not statistically significant. Likewise, when Turner and Richardson (16) applied oxyfluorfen at 0.44 pound per acre pre-emergence to lodgepole pine in a greenhouse, they found no significant phytotoxic effects.

Although oxyfluorfen was effective in controlling weeds in this study, weed growth was not heavy, even on the control plots. The times here translate into 2.7 worker hours to weed 1,000 linear feet of control plot compared to 0.6 and 0.9 worker hours per 1,000 feet of sprayed plots. Because seedbeds are fumigated after each crop of seedlings, weed growth was especially sparse the first growing season. The April application was effective in preventing weed growth, and June applications further improved the weed control a little bit.

Most other studies also report more effective results using pre-emergence oxyfluorfen sprays compared to postemergence. In concentrations of 0.5 to 1.0 pound per acre (14), 0.25 pound per acre (1), and 0.11 to 0.89 pound per acre (18) oxyfluorfen was successful in weed control when sprayed pre-emergence. Postemergence tests in these three studies give mixed results.

It appears that oxyfluorfen can control weeds in nursery beds at Lucky Peak Nursery. Weeding times were reduced by 66% with a pre-emergence spray of 0.75 pound per acre and a postemergence spray in April of the second year. The weeding time decreased an additional 10% by spraying again in June of both years. However, oxyfluorfen spray damaged lodgepole pine seedlings, especially when applied as a pre-emergence spray.

Nursery managers could avoid most of the lodgepole pine seedling damage by waiting until the second year to spray with oxyfluorfen. We saw no additional drop in survival and height growth after the first year. To use only hand weeding in the first year may also be the most economical method. Few weeds grew during the first year, even on control plots.

The 1.5-pounds-per-acre concentration of oxyfluorfen was stronger than needed. It caused more seedling damage than did the 0.75-pound-per-acre concentration. In fact, concentrations less than 0.75 pound per acre may be adequate in weed control and cause minimal damage to seedlings.

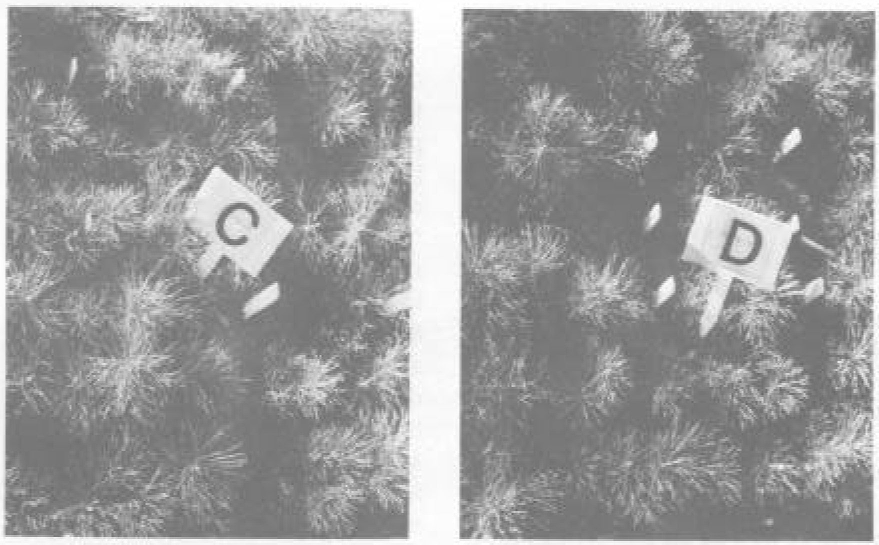

Figure 3—*0.75 pounds per acre pre-emergence and postemergence* **(C).** *1.5 pounds pounds per acre pre-emergence* **(D).**

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