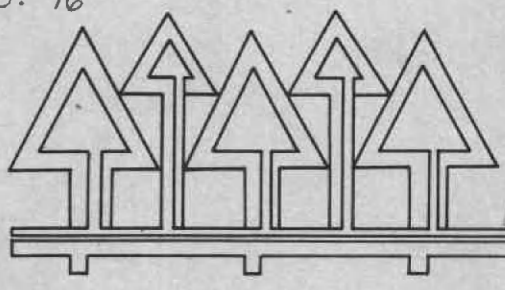

FOREST RESEARCH LABORATORY

RESEARCH NOTE 76

GLYPHOSATE AND HEXAZINONE MIXTURES: EFFECTS ON WEEDS AND DOUGLAS-FIR TRANSPLANTS

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INTRODUCTION

In many forest areas of Oregon, dense stands of grass remove virtually all available moisture in the surface 50 cm of soil by the end of June (Newton 1964, Preest 1973, Zedaker 1982). Low soil moisture results in high plant moisture stress and often in high mortality among young conifers (Newton 1964, Cleary et al. 1978). When successful, herbaceous weed control relieves this stress, but herbicides often fail to produce consistent, safe results on certain perennial grasses.

Glyphosate and hexazinone are both used for control of perennial grasses in plantations. Maximum rates used for perennials have been observed to cause some conifer injury, however, and there is incentive for using minimum rates. The present study was conducted to investigate how weeds and Douglas-fir (Pseudotsuga menziesii) transplants respond to liquid and solid formulations of hexazinone separately and in combination with glyphosate.

MATERIALS AND METHODS

Research plots were established near Corvallis, Oregon, in a mature herbaceous community dominated by oatgrass (Arrhenatherum elatius), velvet grass (Holcus lanatus), blue wild rye (Elymus glaucus), and trailing blackberry (Rubus ursinus). These plots were located on a gentle (20 percent) west-facing slope in the foothills of the Coast Range at 150 m elevation. Soils were well-drained, deep clay loams of the Jory series. Local precipitation averages 1,050 mm per year. During the initial year of the study, however, local precipitation was much higher. August rains were 68 mm -- 54 mm more than the average for this month -- and contributed to generally enhanced survival.

Thirty-two plots, each 3 by 14 m, were established in March 1979. Each was planted with twenty 3-year-old Douglas-fir transplants averaging 45 cm tall but with root-to-shoot ratios of about 1:4. In April 1979, herbicides were applied with a backpack pressurized sprayer connected to a hand-held, 3-m boom containing 6 flat fan nozzles delivering 122 liters/ha (13 gal/acre). Warm water was used to prevent recrystallization

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of the solid formulation of hexazinone. The experimental design was a randomized complete block factorial, with two replications. Hexazinone liquid and solid formulations were applied at rates of 0, 1.11, 1.68, and 2.23 kg/ha a.i. (1, 1.5, and 2 lb/acre) in combination with glyphosate at rates of 0 and 0.62 kg/ha a.i. (0 and 0.5 lb/acre).

Weed control was evaluated in June, July, and September -- 2, 3, and 5 months after treatment -- by estimating the percentages of the plot areas that were weed-free. The numbers of conifers that were dead, had needle loss or severe needle curl, or had terminal bud dieback were recorded 2 and 3 months after treatment. Survival was recorded after the second growing season, and tree height was recorded after the second and fourth growing seasons.

RESULTS

Weed control was consistent during the second, third, and fifth months after treatment. The data were subjected to arcsin transformation, and an analysis of variance showed no significant difference in weed control between the plots treated with hexazinone solid and liquid formulations. Plots treated with hexazinone at the various rates were not significantly different from each other in weed control but were significantly different (0.01 level) from the controls (Table 1). Weed control in plots treated with hexazinone alone was significantly different from that in plots treated with glyphosate alone or a combination of the two herbicides.

The period that weed control was maintained was also studied by calculating the change in weed-free condition between June and September. Plots treated with the solid formulation of hexazinone had a 13 percent increase in weed cover over this period, and those treated with the liquid formulation had only a 4 percent increase. A three-way analysis of variance, without the controls, showed that the liquid formulation of hexazinone gave a significantly longer term of weed control than did the dry product and that the various rates of application did not give significantly different periods of control.

During the first year, there were no significant differences in tree injury, needle loss or curl, or tip dieback among any of the study plots. This was also true for percentages of dead trees in June.

During July, analysis of the percentages of dead trees showed a significant interaction between the effects of the rates of the two herbicides; that is, the effect of the hexazinone rate was not independent of that of the glyphosate rate, and vice versa. At the lowest rate of hexazinone, addition of glyphosate apparently caused a sharp increase in conifer mortality (Table 2). But at the highest rate of hexazinone, conifer mortality was greater without glyphosate.

TABLE 1.

MEAN PERCENTAGES OF PLOTS WEED-FREE DURING FIRST YEAR AFTER SPRAYING WITH GLYPHOSATE AND HEXAZINONE.[1]

Month and hexazinone rate (kg/ha)	Glyphosate rate (kg/ha)		
	0	0.62	Mean[2]
	Percent weed-free		
June			
0	22.50	60.00	41.25[a]
1.11	77.50	95.00	86.25[b]
1.68	83.75	98.50	91.13[b]
2.23	85.25	95.75	90.50[b]
Mean[3]	67.25[A]	85.06[B]	
July			
0	16.25	47.50	31.86[a]
1.11	67.50	90.00	78.75[b]
1.68	77.50	84.00	80.75[b]
2.23	82.25	87.00	84.63[b]
Mean[3]	60.88[A]	77.13[B]	
September			
0	20.00	37.50	28.75[a]
1.11	67.50	88.25	77.88[b]
1.68	80.00	83.75	81.88[b]
2.23	83.75	90.25	87.00[b]
Mean[3]	62.81[A]	74.94[B]	

[1]All ANOVAS run with arcsine transformation of percentages.

[2]Within each month, means followed by the same letter are not significantly different at the 0.01 level according to Tukey's HSD test.

[3]Within each month, means with and without glyphosate were significantly different at the 0.01 level according to Tukey's HSD test.

Second-year survival of the planted trees was significantly less on plots without hexazinone than on all hexazinone-treated plots, but there was no significant difference in survival among plots treated at the various rates (Table 3). Nor did the formulation of hexazinone significantly affect survival. Glyphosate application significantly decreased survival.

Analysis of second-year tree heights showed significant interactions (0.05 level) between glyphosate rate and hexazinone rate. On plots without hexazinone, the application of glyphosate resulted in increased tree height (Table 4). Trees treated with glyphosate plus hexazinone were always smaller than those treated only with hexazinone, regardless of application rate.

The differences in tree height were still present after the fourth growing season (Table 4). Again, the interaction between glyphosate rate and hexazinone rate was significant (0.05 level). As at the end of the second year, trees were smallest on the plots with no herbicides, taller on plots treated with glyphosate alone, and tallest on plots treated only with hexazinone.

TABLE 2.

MEAN PERCENTAGES OF DEAD TREES IN JULY OF THE FIRST YEAR AFTER SPRAYING WITH HEXAZINONE AND GLYPHOSATE. ANALYSIS OF VARIANCE SHOWED A SIGNIFICANT INTERACTION (0.05 LEVEL) BETWEEN HEXAZINONE RATE AND GLYPHOSATE RATE.

Hexazinone rate (kg/ha)	Glyphosate rate (kg/ha)	
	0	0.62
	Percent dead trees	
0	28.75	16.25
1.11	5.00	30.00
1.68	6.25	5.00
2.23	16.25	10.00

TABLE 3.

MEAN PERCENTAGES OF TREE SURVIVAL DURING SECOND YEAR ON PLOTS TREATED WITH GLYPHOSATE AND HEXAZINONE[1].

Hexazinone rate (kg/ha)	Glyphosate rate (kg/ha)		
	0	0.62	Mean[2]
	Percent survival		
0	36.25	40.00	38.13[a]
1.11	87.50	60.00	73.75[b]
1.68	88.75	77.50	83.13[b]
2.23	77.50	77.50	77.50[b]
Mean[3]	72.50[A]	63.75[B]	

[1]All ANOVAs run with arcsine transformation of percentages.

[2]Means followed by the same letter are not significantly different at the 0.01 level according to Tukey's HSD test.

[3]Means with and without glyphosate were significantly different at the 0.05 level according to Tukey's HSD test.

TABLE 4.

MEAN SECOND- AND FOURTH-YEAR TREE HEIGHTS (CM) ON PLOTS TREATED WITH GLYPHOSATE AND HEXAZINONE. ANALYSIS OF VARIANCE SHOWED A SIGNIFICANT INTERACTION (0.05 LEVEL) BETWEEN HEXAZINONE RATE AND GLYPHOSATE RATE.

Year and hexazinone rate (kg/ha)	Glyphosate rate (kg/ha)	
	0	0.62
Second	Height (cm)	
0	58.25	65.25
1.11	70.25	57.50
1.68	67.75	64.00
2.23	73.75	62.00
Fourth		
0	140.50	158.50
1.11	172.00	144.00
1.68	160.00	154.75
2.23	177.75	142.50

An analysis of covariance was run on the fourth-year heights, with percentage of plots weed-free in June of the first year as the covariant. This analysis allowed us to eliminate variation in grass competition (weediness) among the various plots during June of the first year as a factor affecting tree height. The analysis showed that, even after such elimination, height still varied significantly. This suggests that variation was due to the chemical being applied; that is, chemical toxicity affected tree height. The interaction between glyphosate rate and hexazinone rate remained significant.

DISCUSSION

In most weed control programs, the ultimate purpose is to promote the survival and growth of a crop. Successful elimination of competitors will release all site resources to the crop (Newton 1975). It must be noted, however, that when a crop is broadcast-sprayed with herbicides, a potential for toxic effects on that crop exists.

The present study shows the potential for mortality and reduced growth of crop trees from both weed competition and chemical toxicity. That the untreated plots had high mortality along with a high degree of weediness suggests that mortality is the result of competition. However, the plots treated with glyphosate (alone or in combination with hexazinone) had consistently high mortality along with a low degree of weediness. A similar pattern existed for second- and fourth-year heights: trees treated with glyphosate were shorter than those treated with hexazinone alone. This difference apparently indicates that glyphosate is directly toxic to Douglas-fir even though levels of injury to the treated and untreated trees were not significantly different immediately after application. (The glyphosate label appropriately recommends waiting until one year after planting before broadcast-spraying of conifers.) The lowest rate of hexazinone also resulted in high mortality coupled with good weed control, but the lack of injury and the good height growth on plots treated with higher rates of hexazinone suggest that the mortality at the lowest rate was due to chance.

Our results indicate that applying glyphosate or hexazinone significantly reduced the weed population and that there were no significant differences in weed control between hexazinone formulations. Previously, the solid formulation of hexazinone had been difficult to use and had resulted in inconsistent weed control. Such inconsistency was attributed to the tendency of this compound to crystallize readily and clog spray nozzles and screens. The liquid formulation of hexazinone was developed to alleviate this problem. In the present study, care was taken to ensure precise application of both formulations, and both proved equally effective for initial weed control, although they differed in length of effectiveness over the first season. The cause of the longevity of the liquid formulation's effectiveness is not readily apparent.

SUMMARY

The following were important findings of this study:

1. Douglas-fir survival was increased by herbaceous weed control, even in a wetter-than-average summer.
2. Douglas-fir growth was enhanced at least through the fourth year by hexazinone application at rates of 1.1-2.2 kg/ha, and all rates resulted in good weed control.
3. The advantage in height growth from the hexazinone was reduced by adding glyphosate at the rate of 0.62 kg/ha, but glyphosate alone resulted in better height growth than did no weed control.
4. Weed control persisted longer with liquid hexazinone than with the dry product, although their initial effects were equal.

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