CONCLUSIONS

The results have led to product labeling for forest nursery use and have aided in the elimination of certain herbicides due to unacceptable levels of phytotoxicity or ineffective weed control. An added benefit is that the relationship established between the NTC and herbicide manufacturers has resulted in better wording on the labels specific to forest production nurseries. The NTC herbicide testing program will continue on an annual basis.

EFFECT OF SEVERAL SOIL ACTIVE HERBICIDES USED IN FORESTS OF THE PACIFIC NORTHWEST ON GERMINATION OF SEVERAL COMMON HARDWOOD SPECIES.

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INTRODUCTION

There presently are several herbicides available for use in forest regeneration in the Pacific Northwest. These herbicides are mixed at different ratios and applied at differing rates as determined by the product label, perceived degree of vegetative competition, and the species composition on the site. Much of the research emphasis in the past has centered on how to control existing vegetation and on reducing the establishment of annual and perennial grasses and forbs. Currently soil and foliage active herbicides such as hexazinone, sulfometuron, metsulfuron and atrazine are widely used and are quite effective at preventing successful establishment of grass and forb species. These same herbicides have also been shown to have activity to differing degrees on established woody species.

There is a large bank of knowledge on the influence of the above herbicides on established shrub and tree species but little is known about how these same herbicides affect seed germination and establishment of woody species. Field observations suggest that the many soil active herbicides have greater action on germinating seedlings than on adult plants. There is a need to quantify the effect of these herbicides on germinating woody species. From a management perspective this could provide another tool in the control of such species, especially on sites where high germination rates are expected. For example, on sites adjacent to areas with large number of alders, or regions with historical populations of *Ceanothus*, etc.

MATERIALS AND METHODS

Four of the most common preemergent herbicides used in Pacific Northwest Reforestation (atrazine, hexazinone, sulfometuron, and metsulfuron) were selected to test over 12 common woody species. These species were picked because they readily reproduce via seed and are found across many forest sites west of the Cascades from Northern California to British Columbia. Prior to sowing, the seed were stratified (Table 1).

Treatments. Six rates of each herbicide were tested using seeds from 12 species. The rates ranged from a no herbicide control to nearly double normal operational rates. Operational rates typically fall within the treatment 4 and 5 range. The treatments were applied via a gas powered boom sprayer. All the pots for all species designated to receive a particular dose of each herbicide were placed within a 20 ft^2 area. The appropriate amount of herbicide based on this 20 ft^2 area was added to a 500 ml solution and the entire solution was sprayed evenly over the area. To spray the entire 500 ml of spray solution over the area required several passes with the boom sprayer insuring a continuous cover of herbicide over the entire area.

Eight replications of between 6 and 10 seeds for each species were placed on the surface of a sandy loam potting material in 2 by 3 by 2 inch pots for each herbicide rate treatment. The 2 by 3 inch pots are considered the treatment unit. A thin layer of fine gravel was placed over the seeds to hold them in place during watering. The number of seeds planted per pot was kept constant for each species. More seed of some species were used than others due to the size of the seed and their expected viability.

After planting and receiving herbicide treatments, the pots were placed in a greenhouse and kept watered to insure the best environment possible for the seeds to germinate and establish.

There was not enough seed available for some species to test germination success with all four herbicides. For these species tests were run for only as many herbicides as there was seed available. An outline of which seeds were tested against which herbicides and the number of seeds planted per pot (Table 2).

Measurements. The number of germinating seeds was recorded twice a week for eight weeks following the herbicide treatments. At the end of this time all the seedlings were harvested. Care was taken to keep the root systems of live germinants in tact. The final number of live germinants per pot and the dried weight of these germinants was recorded.

Analysis. An ANOVA procedure was used to test for significant differences in the percentage of successful germinants, the average dried weight of these germinants eight weeks following sowing and treatment with herbicides. The Waller Duncan test was used to determine mean separations among different rates of an individual herbicide for each species-herbicide combination tested.

Table 1.

Test species	Latin name	Common name	Stratification requirements
1	*Cytisus scoparius*	Scotch broom	nick seed coat and soak for 12 h
2	*Cytisus striatus*	Portuguese broom	nick seed coat and soak for 12 h
3	*Sambucus spp*	Elderberry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
4	*Alnus rubra*	Alder	no stratification needed
5	*Rubus parviflorum*	Thimbleberry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
6	*Rubus ursinus*	Trailing Blackberry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
7	*Rubus spectabilis*	Salmonberry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
8	*Prunus emarginata*	Bitter Cherry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
9	*Ceanothus velutinus*	Snowbrush	place seed in 170 F allow to cool over night then cold moist conditions for 90 d
10	*Ceanothus integerrimus*	Deerbrush	place seed in 170 F allow to cool over night then cold moist conditions for 90 d
11	*Populus trichocarpa*	Cottonwood	no stratification needed
12	*Arctostaphylos patula*	Greenleaf Manzanita	place seed in 170 F allow to cool over night then cold moist conditions for 90 d

Table 2.. Plant species tested against the four different herbicides and number of seed planted per pot.

Plant species	Sulfometuron test/seeds	Hexazinone test/seeds	Atrazine test/seeds	Metsulfuron test/seeds
Cytisus scoparius	yes/6	yes/6	yes/6	yes/6
Cytisus striatus	yes/6	yes/6	no	yes/6
Sambucus spp	yes/10	yes/10	yes/10	yes/10
Alnus rubra	yes/10	yes/10	yes/10	yes/10
Rubus parviflorum	yes/6	yes/6	no	no
Rubus ursinus	yes/6	yes/6	no	no
Rubus spectabilis	yes/8	no	no	no
Prunus emarginata	yes/5	yes/5	yes/5	yes/5
Ceanothus velutinus	yes/10	yes/10	yes/10	yes/10
Ceanothus integerrimus	yes/10	yes/10	yes/10	yes/10
Populus trichocarpa	yes/10	yes/10	yes/10	yes/10
Arctostaphylos patula	yes/6	yes/6	yes/6	yes/6

RESULTS AND DISCUSSION

The number of seeds that successfully germinated (emerged from the seed and opened their cotyledons) varied widely with herbicide and species tested. In general, atrazine and hexazinone applications resulted in good to excellent control of all species tested. Sulfometuron effectiveness varied by species as did metsulfuron effectiveness.

Hexazinone and atrazine negatively influenced deerbrush germination success and average dry weight even at the lowest rates applied (Table 3). Neither metsulfuron or sulfometuron influenced germination success even at the highest rates. However, low rates of sulfometuron negatively influenced average germinant dry weight. Only at the highest rate of metsulfuron was a significant reduction of average dry weight observed relative to the control. All four herbicides strongly reduced germination success and average seedling dry weight of snowbrush (Table 3). Even the lowest rate of all four herbicides tested significantly reduced germination success and average seedling dry weight from the untreated controls.

Cottonwood germination success was low in the control treatments ranging from a low of 8% in the hexazinone trial to a high of 19% in the metsulfuron trial (Table 3). The lowest rates of hexazinone, sulfometuron and atrazine tested strongly reduced the germination success and average seedling dry weight of cottonwood germinants. Metsulfuron did not result in a significant reduction of germination success even at the highest rate applied. However, medium to high rates of metsulfuron significantly reduced the average dry weight of cottonwood seedlings.

Germination success and average seedling dry weight of scotch broom were significantly reduced at low rates of both hexazinone and atrazine (Table 3). Sulfometuron did not significantly influence germination success but moderate to high rates did reduce the average seedling dry weight. Differences in germination success for metsulfuron applications varied significantly by treatment. However, germination success did not differ significantly in any one treatment from the untreated check. Metsulfuron resulted in reduced average seedling weight but the magnitude of this was not as great as observed with either hexazinone or atrazine.

Portuguese broom germination success was poor (only 10% in the controls) for the metsulfuron trial and germination success did not vary significantly by rate for this herbicide (Table 3). Differences in average weight were observed but were generally not large and did not correspond well with increasing herbicide rate of metsulfuron. Germination success for both the sulfometuron and hexazinone trials was good. Sulfometuron did not result in significant reductions in germination success but low rates resulted in significant reductions in average seedling dry weight, although these reductions were not large. Hexazinone resulted in significant reductions in germination success and average seedling dry weight at moderate to high rates.

Both sulfometuron and hexazinone significantly reduced germination success and average seedling dry weight of thimbleberry even at low to moderate rates (Table 3). There was not enough available seed to test this species against metsulfuron or atrazine. At moderate to high rates of hexazinone trailing blackberry germination success and average seedling weight were significantly reduced. Sulfometuron had little influence on germination success but significantly reduced average seedling dry weight even at low rates. Trailing blackberry was not tested against metsulfuron or atrazine due to a shortage of available seed. Sulfometuron had little influence on Salmonberry germination success but even low rates strongly reduced the average seedling dry weight observed. Salmonberry was not tested against hexazinone, atrazine or metsulfuron due to a shortage of available seed.

Germination success in the untreated check treatment was good for most species. Unfortunately, three of the species tested failed to germinate in sufficient numbers to perform statistical tests. These three species were bitter cherry, greenleaf manzanita, and elderberry. The seed for these species remained viable throughout the experiment but apparently seed dormancy was not broken. Additionally, the seed used for red alder was of poor viability and only a limited number of seeds germinated.

CONCLUSION

Hexazinone and atrazine application resulted in the most consistent control of all the seed species examined. Sulfometuron resulted in good to excellent control of all species tested with the exception of both broom species. However, the highest rates of sulfometuron resulted in less dry weight of both broom species. Under less ideal conditions the combination of other environmental stresses along with herbicide stress may have resulted in greater scotch and Portuguese broom mortality. This is likely true for all the species examined and it is suspected that if the seeds in this trial had been subjected to even minor moisture stress many of those treated with herbicides would have perished. Growth of true leaves and of extensive root systems was dramatically reduced for most germinants exposed to any of the herbicides (with a few exceptions) which would have strongly limited their ability to successfully establish under field conditions.

Table 3. Mean percent germination and average seedling weight for each species and rate tested.[a]

Treatment	Rate	Deerbrush		Snowbrush		Black cottonwood		Scotch broom		Portuguese broom		Trailing blackberry		Thimbleberry		Salmonberry	
		germ.	wt	germ.	wt	germ.	wt	germ.	wt	germ.	wt	germ.	wt	germ.	wt	germ.	wt
	oz/A	%	mg	%	mg	%	mg	%	mg	%	mg	%	mg	%	mg	%	mg
Hexazinone	0	51 a	210 a	69 a	14 a	7.5 a	4 a	52 a	40 a	52 a	70 a	33 b	60 a	62.3 a	11 a	.	.
Hexazinone	8	26 b	9 b	10 b	3 b	0 b	0 b	30 b	30 ab	50 a	30 a	60 a	4 ab	29 b	2 b	.	.
Hexazinone	16	6 cd	3 cd	0 c	0 c	0 b	0 b	0 c	0 c	0 b	0 c	20 bc	4 ab	6.4 cd	1 b	.	.
Hexazinone	24	14 c	6 c	5 bc	1 c	0 b	0 b	10 c	10 bc	35 a	30 b	22 bc	2 bc	15 c	2 b	.	.
Hexazinone	32	4 cd	1 d	3 bc	1 c	0 b	0 b	5 c	6 c	7.5 b	10 c	8 cd	1 c	4 cd	1 b	.	.
Hexazinone	48	0 d	1d	0 c	0 c	0 b	0 b	3 c	2 c	2.5 b	0.1 c	2 d	1 c	0 d	0 b	.	.
Sulfometuron	0	40 a	24 a	46 a	16 a	13.7 a	14 a	42 a	40 a	60 a	70 a	31 a	7 a	41 a	11 a	57 a	13 a
Sulfometuron	0.75	45 a	11 b	10 b	2 b	5 b	1 b	50 a	30 ab	50 a	40 b	31 a	4 b	31 ab	1 b	39 ab	5 a
Sulfometuron	1.5	36 a	7 bc	8 b	2 b	7.5 ab	2 b	60 a	30 ab	58 a	30 b	15 ab	3 b	8 b	0.1 b	22 b	2 c
Sulfometuron	2.25	35 a	9 bc	5 b	1 b	5 b	1 b	58 a	30 ab	38 a	40 b	29 ab	3 b	19 ab	2 b	45 ab	3 c
Sulfometuron	3	29 a	7 bc	6 b	1 b	1.3 b	1 b	32 a	20 ab	45 a	30 b	13 b	1 b	19 ab	1 b	42 ab	3 c
Sulfometuron	4.5	20 a	6 c	4 b	1 b	1.3 b	1 b	45 a	10 b	55 a	30 b	27 ab	2 b	35 a	2 b	59 a	2 c
Metsulfuron	0	43 a	16 ab	46 a	14 a	18.8 a	6 a	37.5 abc	50 a	10 a	10 a	.	.	.	.	.	.
Metsulfuron	0.15	38 a	19 a	24 b	5 b	16.3 a	2 b	40 ab	40 a	12.5 a	40 a	.	.	.	.	.	.
Metsulfuron	0.3	51 a	12 b	33 ab	4 bc	11.3 a	1 b	52 a	20 b	0 a	0 b	.	.	.	.	.	.
Metsulfuron	0.45	45 a	15 ab	26 b	4 bc	10 a	2 b	25 bc	20 b	7.5 a	10 ab	.	.	.	.	.	.
Metsulfuron	0.6	39 a	13 ab	18 b	4 bc	6.3 a	1 b	32 bc	30 ab	7.5 a	4 b	.	.	.	.	.	.
Metsulfuron	1.2	48 a	11 b	14 b	2 c	5 a	1 b	20 c	20 b	12.5 a	23 ab	.	.	.	.	.	.
Atrazine	0	48 a	17 ac	51 a	17 a	18.8 a	5 a	22 a	21 a	.	.	.	.	.	.	.	.
Atrazine	16	12.5 bc	5 b	1.3 b	1 b	0 b	0 b	8 bc	5 b	.	.	.	.	.	.	.	.
Atrazine	32	0 c	0 c	0 b	0 b	0 b	0 b	0 c	0 b	.	.	.	.	.	.	.	.
Atrazine	48	17.5 b	3 bc	3 b	1 b	0 b	0 b	20 ab	6 b	.	.	.	.	.	.	.	.
Atrazine	64	0 c	0 c	0b	0 b	0 b	0 b	2.5 c	2 b	.	.	.	.	.	.	.	.
Atrazine	80	1.2 c	1 c	1.3 b	1 b	0 b	0 b	5 c	2 b	.	.	.	.	.	.	.	.

[a] Means within a column for each herbicide and species interaction associated with the same letter are not significantly different $p \leq 0.05$.

EARLY RESULTS OF THE 'HERB II' STUDY: EVALUATING THE INFLUENCE VEGETATION CONTROL HAS ON FERTILIZATION AT THE TIME OF PLANTING. Robin Rose and J. Scott Ketchum, Associate Professor and Faculty Research Assistant, Department of Forest Science, Oregon State University, Corvallis, OR 97331-7501.

INTRODUCTION

Fertilization in forest nurseries is a common practice to enhance growth rate and vigor of conifer seedlings. Fertilization has also been tried in the field at the time of planting as a means to enhance reforestation efforts. Early