Screening of Three Pre-emergence Herbicides for Intensive Plantation Management in Michigan

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*Three herbicides were applied to newly planted seedlings of six species—European larch (*Larix decidua *Mill.), Kellogg hybrid pine (*Pinus nigra *Am.* X. P. densiflora *Sieb. and Zucc.), northern red oak (*Quercus rubra *L.), tag alder (*Alnus *B. Ehrh. spp.), black locust* (Robinia pseudoacacia *L.), and ailanthus (*Ailanthus altissima *(Mill) Swingle). Survival and growth and the effectiveness of weed control were assessed at the end of the first growing season. Simazine was the only general purpose herbicide tested that was nontoxic and effective for all species. Diphenamid was safe but ineffective, and hexazinone was effective but safe only at low levels for tag alder and Kellogg hybrid pine.* Tree Planters' Notes 39(2):13-18; 1988.

The suppression or elimination of weed competition can be directly linked to improved crop growth and yield. This axiom is as true in silviculture as in agriculture and horticulture. Many authors have documented impressive improvements in survival and early growth of planted seedlings or cuttings when weed control is maintained (3, 4). Weed control is, therefore, generally considered to be an integral part of intensive forest management of conifers and is requisite for hardwoods (8). The question, then, is how best to achieve good weed control at a reasonable cost without damaging the crop or the site.

The first step to weed control is the removal of existing site vegetation before planting. This can be done in a variety of ways but was done chemically for these investigations. The second step to weed control involves preventing new weeds from invading the planted site, and competing with the crop. This can be done chemically in one of three ways: 1) Use of an herbicide for site preparation that has a residual effect in the soil and is toxic to weeds but not the crop. 2) Use of postplanting pre-emergence herbicides to prevent the germination of weed seeds. 3) Use of postemergence herbicides to kill weeds, either by selective phytotoxicity or by directing application only to the weeds.

The distinction among the methods listed above varies with the characteristics of the herbicides. Hexazinone, for example, acts as a site preparation herbicide that is persistent in the soil and as a selective postemergence herbicide. Simazine and diphenamid, on the other hand, act strictly as in post-planting pre-emergence herbicides, only affecting germinating weed seeds. This investigation was conducted to test the suitability of these three herbicides for use

Table 1—*Herbicides and rates of application used to over-spray dormant newly planted seedlings*

Common name	Application rates kg/ha (lb/acre) ai: Low	Medium	High	Dilution in water liter (gal)
Diphenamid[a]	6.7(6)	9.0(8)	11.2(10)	114 (30)
Simazine[b]	2.2(2)	4.5(4)	6.7(6)	151 (40)
Hexazinone[c]	1.1(1)	1.7(1.5)	2.2(2)	189 (50)

[a]Enide 90 WP, NOR-AM Agricultural Products.
[b]Princep 4L, Ciba-Geigy Corp.
[c]VELPAR L, E.I. duPont de Nemours and Co.

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in post-planting weed control on several forest tree species for which little quantitative information was available.

Methods

Herbicides tested. Three herbicides were chosen for testing: diphenamid, simazine, and hexazinone (table 1). Past experiences with diphenamid and simazine have shown that both are reasonably nontoxic to most woody crops and provide good control of most common weeds (3, 5, 7, 9). Hexazinone is highly phytotoxic, especially to hardwood species, but does show selectivity for some conifer species. It was included to test its effect when sprayed over dormant seedlings. The dual action of hexazinone, as a persistent site-preparation herbicide and as a partially selective postemergence herbicide, make it doubly useful in weed control programs: it can eliminate the need for additional pre-emergence herbicides, or it can be used for overspraying to release seedlings from competing weeds. Each herbicide was applied at three rates: 1) the optimal rate recommended on the label, 2) a suboptimal rate, and 3) a superoptimal rate (table 1).

Seedling production. Six species were selected to represent a range of growth types: European larch (*Larix decidua* Mill.), Kellogg hybrid pine (*Pinus nigra* Arn. X. P. *densiflora* Sieb. and Zucc.), northern red oak (*Quercus rubra* L.), tag alder (*Alnus* B. Ehrh. Spp.), black locust *(Robinia pseudoacacia* L.), and ailanthus (*Ailanthus altissima* [Mill.] Swingle). Red oak is commercially important in the Lake States, and the others have been shown to have potential for future use. Tree improvement programs are currently under way for these species at Michigan State University.

Black locust seedlings for this study were produced in nursery beds as standard 1+0 stock during 1984. Containerized seedlings of all the other species mentioned above were produced during 1984. Seeds were sown in poly-coated paper plant bands 5 cm x 5 cm x 29 cm in size. The bands were filled with a medium composed of three parts of peat moss, one part of vermiculite, and one part of per- lite. Seedlings were grown for 4 months under 16-hour photoperiods in the greenhouse and then moved outside to acclimate under 50% shade in the fall of 1984. The seedlings were mulched and held in covered overwintering houses until the spring of 1985, when they were removed from their bands, barerooted, sorted, and stored in a cold room before planting.

Site selection and planting. A site in East Lansing, MI, was selected for the test planting. Soil from the test site was analyzed by the Michigan State University crop and soil science department (table 2). The site was mowed during the summer of 1984 and sprayed with 3.4 kg/ ha (3 pounds per acre) glyphosate (ROUNDUP) to kill weed regrowth in the early fall of 1984. The glyphosate treatment was repeated the following spring, 2 days before planting, to ensure

Table 2—*Analysis of soil in the Ap horizon of the planting site in East Lansing, MI*

	Analysis
Texture	
Soil series	Owosso-Marlette sandy loam
Sand fraction	63%
Silt fraction	18%
Clay fraction	19%
Organic matter	1.4%
Chemical characteristics	
pH	5.3
P content	27 kg/ha (24 lbs/acre)
K content	104 kg/ha (93 lbs/acre)
Ca content	717 kg/ha (640 lbs/acre)
Mg content	100 kg/ha (89 lbs/acre)

total preplanting weed control.

Seedlings were planted on June 6, 1985, with a subsoiling tree planter, which made a 30-cm-deep (12-inch-deep) planting slit. The plantation was established in a split-plot complete randomized block design with 6 blocks using 4-tree linear subplots for ease of herbicide application. Six species comprised the subplots, and 9 herbicide treatments and one untreated control were the mainplot effects. Planted rows were 1.2 m (4 feet) apart, and trees were planted 0.6 m (2 feet) apart within the rows. Data were analyzed, however, on a species-by-species basis, ignoring the splitplot nature of the design and treating the plantation as a complete randomized block design.

Because soil moisture was extremely low at the time of planting, a standard sprinkler irrigation system was installed on the site. Approximately 2.5 cm (1 inch) of water was applied after planting and before treatment with herbicides.

Table 3—*Weeds present on test site, 3 months after application of weed control*

Common name	Latin name	Weed status
Tumble pigweed	*Amaranthus albus* L.	d,h,s
Common ragweed	*Ambrosia artemisiifolia* L.	d
Yellow rocket	*Barbarea vulgaris* R. Br.	d,s
Shepherd's-purse	*Capsella bursa-pastoris* (L.) Medikus	d,h,s
Common lamb's-quarters	*Chenopodium album* L.	d
Horseweed	*Conyza canadensis* (L.) Cronq.	d
Wild carrot	*Daucus carota* L.	d
Hairy crabgrass	*Digitaria sanguinalis* (L.) Scop.	d,h,s
Quackgrass	*Elytrigia repens* (L.) Nevski	d
Stinkgrass	*Eragrostis cilianensis* (All.) Lutati.	d
Rough fleabane	*Erigeron strigosus* Muhl.	d
Wild strawberry	*Fragaria virginiana* Duchesne	d
Tall lettuce	*Lactuca canadensis* L.	d
Field pepperweed	*Lepidium campestre* (L.) R. Br.	d
Black medic	*Medicago lupulina* L.	d,s
Common yellow woodsorrel	*Oxalis stricta* L.	d
Witchgrass	*Panicum capillare* L.	d,h,s
Pokeweed	*Phytolacca americana* L.	d
Buckhorn plantain	*Plantago lanceolata* L.	d,h
Purslane	*Portulaca oleracea* L.	d,h,s
Silver cinquefoil	*Potentilla argentea* L.	d,h
Red sorrel	*Rumex acetosella* L.	d,h,s
Curley dock	*Rumex crispus* L.	d
Yellow foxtail	*Setaria pumila* (Poiret) Roemer & Schultes	d
White cockle	*Silene alba* (Miller) Krause	d
Common chickweed	*Stellaria media* (L.) Villars	d
Red clover	*Trifolium pratense* L.	d
Common mullein	*Verbascum thapsus* L.	d

d = Weeds present in diphenamid treatments, h = weeds present in hexazinone treatments, and s = weeds present in simazine treatments.

Treatment and Analysis

Herbicides were sprayed over the seedlings the day after planting using a tractor-mounted boom-type sprayer. The boom was arranged to spray a 1.2-m (4-foot) strip through two 8006 flat fan nozzles at 40 psi. Tractor speed was varied to achieve the recommended application rates listed in table 1. No rain fell for 24 hours after herbicide treatment, so irrigation was resumed on June 9, 1985, and continued as necessary so that moisture did not limit the growth or survival of the seedlings. When rainfall became normal by mid-July, irrigation was discontinued.

The effect of the herbicides on the weeds and trees was monitored throughout the growing season, and final measurements were made on September 3, 1985. The total height of all seedlings was measured, and plot means were computed. Plot survival was determined and expressed in percent. Survival data were transformed using the arc-sine date transformation (6) to yield a variable that was normally distributed. A summary of the weed population in each treatment was also made. An analysis of variance in total height and transformed survival was performed. As previously mentioned, the split-plot nature of the plantation design was ignored and data analyses were conducted independently for each species.

Results and Discussion

Weed control effectiveness. Weed control on the test site was good for all herbicide treatments during the first month of the test. During the second month, differences became apparent, and by the third month it was possible to identify the acceptable and unacceptable treatments. Diphenamid, when applied under these conditions, gave completely unacceptable weed control. Twenty-eight species of weeds were identified in the untreated control plots 3 months after treatment. These same weeds were found, growing vigorously, in all diphenamid-treated plots as well. In contrast, only 8 of these species were found in significant levels in the hexazinoneand simazine-treated plots (table 3).

The vigor of the weed growth varied among the treatment levels of hexazinone and simazine. Complete weed control (100%) was achieved at the highest level of hexazinone. Acceptable weed control (about 80%) was achieved at the medium level of hexazinone and the highest level of simazine. Approximately 50% weed control was achieved with the lowest level of hexazinone and the medium level of simazine. The lowest level of simazine gave unacceptable weed control.

Effects on height growth. Significant differences among treatments for height were only found for red oak (table 4). No treatments were associated with significantly taller or shorter seedling height than the control,

Table 4—*Mean plot heights of plots of seedlings under nine herbicide and one control treatments, 3 months after planting*

	Average height (mm)					
Herbicide treatment	European larch	Red oak	Tag alder	Ailanthus	Black locust	Kellogg hybrid pine
Diphenamid						
Low	224	306	454	401	700	117
Medium	205	210	414	378	643	127
High	263	332	398	252	728	108
Hexazinone						
Low	190	216	536	226	598	113
Medium	208	241	446	290	623	126
High	160	244	442	462	Dead*	109
Simazine						
Low	251	313	368	405	781	138
Medium	258	246	504	297	654	127
High	176	253	503	334	624	127
Control	228	280	480	271	658	138
LSD[a]	NS	80	NS	NS	NS	NS

[a]LSD computed for the comparison of 2 means with alpha = 0.05.
NS = Differences not significantly different at alpha = 0.1.
*All black locust were killed under this herbicide treatment.

however, and no significant trends existed among levels of any one herbicide. The herbicides neither increased nor decreased the height growth of treated seedlings in comparison to untreated seedlings. This indicates not only that surviving seedlings were not affected by the presence of herbicide in the soil but also that there was no positive benefit from the removal of weed competition from the site during the first year after planting.

This second result is unexpected since many researchers have concluded just the opposite (4). The lack of improvement in height growth under low weed competition may be due to one or a combination of three factors: 1) Growth was only measured for 3 months, and significant differences may take longer to develop. 2) Water competition from weeds is often cited as one cause for reduced crop growth, but irrigation kept water nonlimiting throughout most of this test. 3) The nutrient status of the test site was poor and may have been growth-limiting under all treatments.

Effects on survival. Herbicide treatment had no significant effect on the survival of Kellogg hybrid pine, tag alder, and red oak, but mortality of European larch, ailanthus, and black locust treated with all levels of hexazinone was significantly greater than the control (table 5). Even though hexazinone did not significantly reduce the survival of red oak below control levels, the leaf margins of the oak seedlings were burned, indicating mild herbicide damage. Previous reports indicate that red oak and other oaks are killed by hexazinone (2), but this mortality may be at concentrations higher than those tested here. Until more data are available, hexazinone should not be used on red oak.

Hexazinone has previously been shown to be safe for use over Scotch pine (*Pinus sylvestris* L.) and red pine (*P. resinosa* Ait.) in unpublished studies at Michigan State University, relatively safe for use on ponderosa pine (*P. ponderosa* (Engelm.) Shaw) and Douglas-fir (*Pseudotsuga*

Table 5—*Summary of mean plot survival over 6 blocks of 6 species under 9 herbicide and one control treatments, 3 months after planting*

Herbicide treatment	Percent survival (arc-sine transform of survival)					
	European larch	Red oak	Tag alder	Ailanthus	Black locust	Kellogg hybrid pine
Diphenamid						
Low	100 (1.6)	88 (1.2)	92 (1.3)	88 (1.2)	62 (0.8)	100 (1.6)
Medium	79 (1.1)	79 (1.1)	83 (1.2)	88 (1.2)	71 (1.0)	100 (1.6)
High	83 (1.2)	96 (1.4)	79 (1.1)	92 (1.3)	83 (1.2)	100 (1.6)
Hexazinone						
Low	12 (0.1)	75 (1.0)	79 (1.1)	54 (0.7)	12 (0.1)	96 (1.4)
Medium	12 (0.1)	71 (1.0)	96 (1.4)	67 (0.8)	12 (0.1)	100 (1.6)
High	12 (0.1)	87 (1.2)	75 (1.0)	21 (0.3)	0 (0.0)	96 (1.4)
Simazine						
Low	92 (1.3)	79 (1.1)	88 (1.2)	96 (1.4)	67 (0.8)	100 (1.6)
Medium	88 (1.2)	79 (1.1)	79 (1.1)	96 (1.4)	71 (1.0)	100 (1.6)
High	88 (1.2)	92 (1.3)	92 (1.3)	96 (1.4)	67 (0.8)	96 (1.4)
Control	92 (1.3)	96 (1.4)	92 (1.3)	92 (1.3)	79 (1.1)	96 (1.4)
LSD[a]	— (0.4)	NS	NS	— (0.5)	— (0.5)	NS

[a]LSD computed for the comparison of 2 means with alpha = 0.05.
NS = Differences not significantly different at alpha = 0.1.

menziesii [Mirb.] Franco) by Stewart (7), and on several southern pines (1). This list may now be expanded to include Kellogg hybrid pine and tag alder on coarse soils at these rates.

Simazine and diphenamid had no effect on survival at the rates tested.

Conclusions

Because height growth was unaffected by herbicide treatment in this study, treatment effectiveness was determined by seedling survival and quality of weed control. Even though all diphenamid treatments and the lowest level of simazine did not adversely affect the seedlings, they produced unacceptable weed control and therefore cannot be recommended. Hexazinone gave excellent weed control but was nontoxic only to tag alder and to Kellogg hybrid pine at the levels tested; it is of value, nonetheless, for release spraying in established plantations of other species. Simazine at 4 or 6 pounds of active ingredient per acre gave good weed control, was not toxic to any of the species (European larch, Kellogg hybrid pine, red oak, tag alder, black locust, and ailanthus), and therefore was the only acceptable, general-purpose herbicide tested under these conditions.

Literature Cited

1. Neary, D.G.; Bush, P.D.; Douglass, J. E. 2-, 4-, and 14-Month efficacy of hexazinone for site preparation. Proceedings of the Southern Weed Science Society 34:181-191; 1981.
2. Newton, M.; Knight, F.B. Hand book of weed and insect control chemicals for forest resource managers. Beaverton, OR: Timber Press; 1981.
3. Ontario Ministry of Natural Resources. New forests in eastern Ontario: hybrid poplar. Sci. Tech. Ser. 1. Ottawa: Queen's Printer for Ontario; 1983. 336 p.
4. Perala, D.A. Early release: current technology and conifer response. In: Mroz, G.D.; Berner, J.F., ed. Proceedings, Conference on artificial regeneration of conifers in the upper Great Lakes region, 26-28 October 1982; Green Bay, WI. 1982: 39610.
5. Reighard, G.L.; Howe, G.; Hanover, J.W. Effects of chemical weed control and seedling planting depth on survival and growth of aspen. Tree Planters' Notes 36(1):3-7; 1985.
6. Snedecor, G.W.; Cochran, W.G. Statistical methods, 6th edition. Ames: Iowa State University Press; 1979.
7. Stewart, R.E.; Owston, P.W.; Weatherly, H.G. Evaluation of six herbicides for weed control in Pacific coast forest nurseries. In: Proceedings, Western Forest Nursery Council and Intermountain Nurseryman's Association Conference; 1978 August; Eureka, CA. 1978: 8127-B133.
8. von Althen, F.W. Site preparation and post-planting weed control in hardwood afforestation: white ash, black walnut, basswood, silver maple, hybrid poplar. Rep. O-X-325. Sault Ste. Marie, ON: Canadian Forestry Service; 1981.17 p.
9. Warmund, M.R.; Geyer, W.A.; Long, C.E. Preemergent herbicides for direct seeding Kentucky coffeetree, honeylocust, and black locust. Tree Planters' Notes 35(3):24-27; 1983.