HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

Evaluation of Six Herbicides for Potential Use in Tree Seed Beds[1]

S.L. Warren and W.A. Skroch[2]
Department of Horticultural Science
North Carolina State University
Raleigh, NC 27695-7609

Abstract

Five herbicides, Pennant, Surflan, Devrinol, Ornamental Herbicide 2, and Ronstar, were applied over newly seeded deciduous trees immediately after seeding and Poast was applied when seedlings were actively growing. The trees were river birch, pin oak, willow oak, redbud, flowering dogwood, sugar maple, and sweet gum. No seedlings were damaged by Pennant (4.5 kg/ha) or Poast. Ornamental Herbicide 2 and Ronstar severely damaged river birch, flowering dogwood, and sugar maple. Surflan damaged sugar maple. Devrinol damaged flowering dogwood. Data herein suggest that each species must be evaluated separately for herbicide tolerance.

Index words: phytotoxicity, weed control, deciduous trees

Herbicides used in this study: Pennant (metolachlor), 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide; Surflan (oryzalin), 4-(dipropylamino)-3,5-dinitrobenzenesulfonamide; Devrinol (napropamide), N,N-diethyl-2-(1-naphthalenyloxy)propanamide; OH-2 (oxyfluorfen), 2-chloro-1-(3-ethoxy-4-nitrophenoxy)4-(tri-fluoromethyl)benzene + (pendimethalin), N-(1-ethylpropyl)3-4-dimethyl-2,6-dinitrobenzenamine; Ronstar (oxadiazon), 3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3H)-one; Poast (sethoxydim), 2-[1-(ethoxyimino)butyl]-5-[2(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one.

Species used in this study: River birch (*Betula nigra* L.); Pin oak (*Quercus palustris* Muenchh.); Willow oak (*Quercus phellos* L.); Redbud (*Cercis canadensis* L.); Flowering dogwood (*Cornus florida* L.); Sugar maple (*Acer saccharum* Marsh.); Sweet gum (*Liquidambar styraciflua* L.); Red maple (*Acer rubrum* L.).

Significance to the Nursery Industry: Hand weeding hardwood seedbeds costs several thousand dollars per hectare. Herbicides could be cost effective weed control alternatives. The preemergence herbicide Pennant (4.5 kg/ha) and the postemergence herbicide Poast produced no detectable damage on the seven species tested. The preemergence herbicides Ronstar, Devrinol, Surflan, and Ornamental Herbicide 2 (OH-2) injured one or more species in this study. With further testing these data should give nurserymen some additional alternatives for future weed management decisions.

Introduction

Abrahamson (3) reported that it required an average of 699 man hr/ha (283 man hr/A) to hand weed hardwood seedbeds. South (7) reported 8% mortality from cultivation of 12-week old hardwood seedlings. With fumigation, the primary means of weed control, costing over $2471/ha ($1000/A) and the problems with reducing endomycorrhizal fungi, researchers have been examining selective herbicides as an alternative for hardwood seedbeds (10). However, only limited research has been conducted to determine the tolerance of deciduous trees to herbicides when grown from seed (6).

Abrahamson (1, 2, 3), South (6, 7), and South and Gjerstad (8, 9) have tested potential herbicides for use in seedbeds of hardwood trees used for reforestation. Abrahamson (1, 2, 3) reported Devrinol, Goal, and Ronstar damaged yellow birch (*Betula alleghaniensis* Britt.). Silky dogwood (*Cornus amomum* Mill.) and sugar maple tolerated Devrinol, but were damaged by Ronstar (1, 2, 3). South (6) reported damage to sweet gum with Devrinol and Ronstar, but not with Surflan. However, in another report South (8) suggests that Devrinol can be used for weed control in sweet gum. Warmund (12) used sethoxydim and fluazifop for controlling oats (*Avena* sp.) in direct-seeded nursery beds without damage to emerged seedlings.

Since tolerance to herbicides varies with species, this study was initiated to determine herbicide tolerance of eight species of deciduous trees.

Materials and Methods

The experiment was conducted at the Mountain Horticultural Crops Research Station [35°26′N, 82°34′W, elev. 631 m (2051 ft)], Fletcher, NC. In September 1986, the Hayesville clay loam soil (clayey, oxidic, mesic, typic hapludult) was fumigated with methyl bromide, 49 g/m^2 (1.0 lb/100 ft^2), and amended to meet the pH and fertility levels recommended for tree seedlings (11). Raised beds were constructed and individual plots, 1.5 m × 2.4 m (5 × 8 ft), were laid out in a randomized complete block design with 4 blocks. There were 0.6 m (2 ft) between each plot.

Mature seeds of flowering dogwood, pin oak, redbud, sweet gum, and sugar maple were collected locally, willow oak seed was collected in Raleigh, NC, during Fall, 1986. Mature seeds of red maple and river birch were collected locally during Spring, 1987. Seeds were harvested, stored, and planted according to Schopmeyer (5). Before planting, each plot was subdivided into two subplots, 1.5 × 1.2 m (5 × 4 ft). Fall-seeded species (flowering dogwood, pin

[1]Received for publication December 4, 1990. In revised form May 25, 1991. The research reported in this publication was funded by the North Carolina Agricultural Research Service, Raleigh, NC 27985-7643. Technical assistance of Robert Wooten, Everett Whitman, and the staff of the Mountain Horticultural Crops Research Station are gratefully acknowledged.

[2]Associate Professor and Professor, respectively.

oak, willow oak, and sugar maple) were randomly assigned to one of the two subplots in each plot; spring-seeded species (river birch, redbud, sweet gum, and red maple) were assigned to the remaining subplot. Each subplot was divided into four equal sub-subplots. Each species was randomly assigned to a sub-subplot. Forty-nine seeds of each species were planted, equidistant 7.6 × 7.6 cm (3 × 3 in), within the sub-subplot. Flowering dogwood, pin oak, willow oak, and sugar maple were planted Dec. 3, 1986. Preemergence herbicide treatments included Pennant 5G, 4.5 kg/ha (4 lb ai/A) and 9.0 kg/ha (8 lb ai/A); Surflan 5G, 4.5 kg/ha (4 lb ai/A); Devrinol 50WP, 4.5 kg/ha (4 lb ai/A); Ornamental Herbicide 2 (OH-2), 3G, 3.4 kg/ha (3 lb ai/A) and 6.8 kg/ha (6 lb ai/A); Ronstar 2G, 4.5 kg/ha (4 lb ai/A) and 9.0 kg/ha (8 lb ai/A) were applied immediately following planting. Granular herbicides were applied via a hand-held shaker jar. Devrinol was applied via a CO_2 backpack sprayer equipped with 49 × 49 whirljet nozzles delivering 168 l/ha (18 gal/A) at 138 kpa (20 psi). After herbicide application, beds were covered with 2.5 cm (1 in) of aged sawdust. Subplots designated for spring-seeded species did not receive this herbicide application until after spring planting.

River birch, redbud, red maple, and sweet gum were planted June 1, 1987. Preemergence herbicide treatments listed previously were applied to the plot (fall-seeded and spring-seeded subplots) immediately after planting. After herbicide application, the spring-seeded subplots were covered with 2.5 cm (1 in) of aged sawdust. Preemergence herbicide treatments were reapplied Sept. 25, 1987 and March 2, 1988 to the entire plot. Poast 1.53E, 0.55 kg/ha (0.5 lb ai/A) plus crop oil 1% v/v was applied when the trees were actively growing on June 29 and August 28, 1987, and May 13, 1988 to the entire plot via a CO_2 backpack sprayer equipped with 49 × 49 whirljet nozzles delivering 168 l/ha (18 gal/A) at 138 kpa (20 psi).

Ammonium nitrate (33% N) was surface applied at 38 kg/100 m^2 (75 lbs/1000 ft^2) on June 29, 1987 and April 10, 1988. Water was applied as needed via overhead irrigation and weeds were removed by hand.

Surviving trees were counted June 8 (fall-seeded only), Aug. 5, and Dec. 14, 1987, and May 25, 1988. Plants were evaluated Aug. 5, 1987, and May 25, 1988 for phytotoxicity on a scale of 0 to 100, with 0 = dead plants and 100 = no visible foliar injury.

On August 26, 1987, five seedlings were randomly selected from each species, excluding border plants. Shoots (aerial tissue) were removed at the soil surface and roots were manually excavated and washed. Shoots and roots were dried at 70°C (158°F) for 6 days then weighed to obtain shoot and root dry weight. Before harvest, height (measured from soil surface to the terminal bud) and diameter (measured at the soil surface) were determined. Before drying, leaf area for flowering dogwood and sweet gum was measured with a LI-3000 leaf area meter (LI-COR, Lincoln, NE).

On June 5, 1988, five seedlings were randomly selected from each species, excluding border plants. Identical harvesting procedures and growth measurements were followed as outlined previously, except roots were not excavated.

All variables were tested for differences using analysis of variance, with means separated by Fisher's least significant difference at $p = 0.05$.

Results and Discussion

Shoot dry weight, root dry weight, leaf area (where applicable), and phytotoxicity ratings from 1987 were highly correlated ($r > 0.88$, $p = 0.001$) with height and diameter. Similarly, shoot dry weight, leaf area (where applicable), and phytotoxicity ratings in 1988 were highly correlated ($r > 0.90$, $p = 0.001$) with height and diameter. In addition, tree seedlings are standardized by height and diameter (caliper) (4); therefore only height and diameter will be presented. Results were similar from both harvest dates (August 26, 1987 and June 5, 1988); therefore, only data for the June 5, 1988 harvest are presented. Because red maple germination was poor, those data are not presented. Each species will be discussed separately.

Redbud. The 6.8 kg/ha rate of OH-2 reduced height and diameter by 35 and 27%, respectively, compared to the untreated check (Table 1). In addition, Surflan reduced seedling survival by 13%.

River birch. This species was killed by Ronstar at the 9.0 kg/ha rate and severely damaged from the 4.5 kg/ha rate of Ronstar and the 6.8 kg/ha rate of OH-2 (Table 1). Height and diameter were not significantly affected by Pennant, Devrinol, OH-2 (3.4 kg/ha), or Poast. However, survival was reduced 45% by the 3.4 kg/ha rate of OH-2.

Table 1. Height, diameter, and survival of redbud, river birch, and sweet gum seedlings after three herbicide applications.

Herbicide	Formulation	Rate kg/ha (lb ai/A)	Redbud Ht[z] (cm)	Redbud Dia[y] (mm)	Redbud Survival (%)	River birch Ht (cm)	River birch Dia (mm)	River birch Survival (%)	Sweet gum Ht (cm)	Sweet gum Dia (mm)	Sweet gum Survival (%)
Pennant	5G	4.5 (4)	94 a[x]	7.8 a	89.1 abc	100 a	8.7 a	68.6 a	59 abc	6.8 a	49.4 abc
Pennant	5G	9.0 (8)	86 a	8.0 a	82.1 cd	86 ab	8.1 ab	53.8 ab	56 abc	6.4 a	41.9 abc
Surflan	5G	4.5 (4)	84 a	7.8 a	77.6 d	56 bc	6.4 ab	47.9 ab	56 abc	6.0 a	37.8 abc
Devrinol	50WP	4.5 (4)	85 a	8.0 a	84.6 bcd	101 a	9.2 a	63.5 a	62 ab	6.4 a	62.2 ab
OH-2	(2+1)G	3.4 (2+1)	75 ab	7.3 a	87.8 abc	82 ab	8.2 ab	37.8 b	47 bc	8.4 a	44.2 abc
OH-2	(2+1)G	6.8 (4+2)	55 b	5.7 b	91.5 ab	42 dc	4.6 bc	12.2 c	17 d	6.8 b	6.8 d
Ronstar	2G	4.5 (4)	85 a	8.1 a	87.8 abc	12 de	1.7 dc	2.6 c	53 abc	7.7 a	41.0 abc
Ronstar	2G	9.0 (8)	72 ab	7.0 a	95.5 a	0 e	0.0 d	0.0 c	43 c	7.4 a	21.8 cd
Poast	1.53E	0.55 (0.5)	94 a	7.7 a	91.7 ab	104 a	9.0 a	67.3 a	55 abc	7.4 a	60.9 ab
Check			84 a	7.8 a	89.1 abc	106 a	8.8 a	69.2 a	67 a	7.3 a	66.0 a

[z]Height from soil surface to terminal bud.

[y]Diameter measured at the soil surface.

[x]Means within a column followed by the same letter or letters are not significantly different, $p = 0.05$.

Sweet gum. OH-2, at the 6.8 kg/ha rate, reduced height, diameter, and survival by 75, 7, and 90%, respectively, compared to the check (Table 1). In addition, Ronstar and OH-2 (3.4 kg/ha) suppressed height and Ronstar reduced % survival.

Willow oak. Pennant (9.0 kg/ha), Surflan, and Devrinol reduced seedling height by 36, 30 and 29%, respectively, compared to the check (Table 2). Surflan also reduced survival by 19%. Diameter was not significantly affected by herbicide treatments.

Pin oak. The 9.0 kg/ha rate of Pennant reduced seedling height, diameter, and survival by 40, 19 and 16%, respectively, compared to the check (Table 2). The seedlings were not significantly affected by the other herbicides. The difference in response of the two oak species illustrates that even species within the same genus may vary in their response to the same herbicides. Both species were damaged by the 9.0 kg/ha rate of Pennant, however, Surflan and Devrinol reduced the height of willow oak seedlings while pin oak seedlings were not affected.

Flowering dogwood. Ronstar (4.5 and 9.0 kg/ha) and the 6.8 kg/ha rate of OH-2 eliminated all seedlings (Table 3). OH-2 (3.4 kg/ha), Surflan, and Devrinol severely reduced % survival and seedling height.

Sugar maple. OH-2 (3.4 and 6.8 kg/ha), Ronstar (4.5 and 9.0 kg/ha), and Surflan nearly eliminated all seedlings (Table 3). Pennant, Devrinol, and Poast did not affect seedling growth and survival.

Pennant at 4.5 kg/ha and Poast at 0.55 kg/ha caused no detectable damage to the seedlings. Due to the variability between hardwood species in their responses to herbicides, it can be concluded that each species must be evaluated separately for herbicide tolerance.

(**Ed. note:** This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.)

Table 2. Height, diameter, and survival of willow oak and pin oak seedlings after four herbicide applications.

Herbicide	Formulation	Rate kg/ha (lb ai/A)	Willow oak Ht[z] (cm)	Willow oak Dia[y] (mm)	Willow oak Survival (%)	Pin oak Ht (cm)	Pin oak Dia (mm)	Pin oak Survival (%)
Pennant	5G	4.5 (4)	55 abc[x]	6.8 a	82.3 ab	77 b	8.7 bc	82.5 ab
Pennant	5G	9.0 (8)	42 c	6.4 a	75.3 ab	49 c	7.0 d	75.0 b
Surflan	5G	4.5 (4)	46 bc	6.0 a	70.1 b	83 a	8.9 bc	80.0 ab
Devrinol	50WP	4.5 (4)	47 bc	6.3 a	86.8 a	66 b	8.2 c	84.2 ab
OH-2	(2+1)G	3.4 (2+1)	67 a	8.4 a	89.4 a	93 a	10.2 a	85.0 ab
OH-2	(2+1)G	6.8 (4+2)	51 abc	6.8 a	85.5 a	78 b	9.3 abc	87.5 ab
Ronstar	2G	4.5 (4)	59 abc	7.7 a	88.1 a	89 a	9.5 ab	85.0 ab
Ronstar	2G	9.0 (8)	56 abc	7.4 a	83.6 ab	86 a	8.9 bc	90.0 a
Poast	1.53E	0.55 (0.5)	58 abc	7.4 a	87.4 a	86 a	8.8 bc	86.7 ab
Check			66 ab	7.3 a	86.8 a	82 ab	8.6 bc	89.2 a

[z]Height from soil surface to terminal bud.

[y]Diameter measured at the soil surface.

[x]Means within a column followed by the same letter or letters are not significantly different, p = 0.05.

Table 3. Height, diameter, and survival of flowering dogwood and sugar maple seedlings after four herbicide applications, respectively.

Herbicide	Formulation	Rate kg/ha (lb ai/A)	Flowering dogwood Ht[z] (cm)	Flowering dogwood Dia[y] (mm)	Flowering dogwood Survival (%)	Sugar maple Ht (cm)	Sugar maple Dia (mm)	Sugar maple Survival (%)
Pennant	5G	4.5 (4)	77 a[x]	8.5 a	82.1 a	36 a	4.7 b	61.6 a
Pennant	5G	9.0 (8)	68 a	8.1 a	64.7 b	34 a	4.9 b	62.5 a
Surflan	5G	4.5 (4)	40 b	6.4 ab	14.7 cd	3 b	0.7 c	3.8 b
Devrinol	50WP	4.5 (4)	41 b	6.3 ab	28.8 c	38 a	6.6 a	55.0 a
OH-2	(2+1)G	3.4 (2+1)	29 b	4.7 b	5.8 de	3 b	0.4 c	2.6 b
OH-2	(2+1)G	6.8 (4+2)	0 c	0 c	0.0 e	0 b	0 c	0.0 b
Ronstar	2G	4.5 (4)	0 c	0 c	0.0 e	0 b	0 c	0.0 b
Ronstar	2G	9.0 (8)	0 c	0 c	0.0 e	0 b	0 c	0.0 b
Poast	1.53E	0.55 (0.5)	75 a	8.7 a	78.2 ab	35 a	5.6 ab	65.9 a
Check			73 a	8.0 a	82.7 a	47 a	6.1 ab	57.6 a

[z]Height from soil surface to terminal bud.

[y]Diameter measured at the soil surface.

[x]Means within a column followed by the same letter or letters are not significantly different, p = 0.05.

Literature Cited

1. Abrahamson, L.P. 1985. Forest tree nursery herbicide studies in the Northern Great Plains: Herbicide phytotoxicity tables. Proc. Intermountain Nurserymen's Assn. p. 58–67.

2. Abrahamson, L.P. 1986. Forest tree nursery herbicide studies in the Great Plains, the Lake States, and in New York: Herbicide phytotoxicity tables. Proc. Intermountain Nurserymen's Assn. p. 17–53.

3. Abrahamson, L.P. 1987. Forest tree nursery herbicide studies at the Oklahoma Forest Regeneration Center. Proc. Intermountain Forest Nursery Assn. p. 49–57.

4. Anonymous. 1990. American standard for nursery stock. Amer. Assoc. of Nurserymen, Inc., Washington, DC. p. 30.

5. Schopmeyer, C.S. (ed.), 1974. Seeds of woody plants in the United States. Agric. Handbook 450., Forest Service, U.S.D.A., Washington, DC.

6. South, D.B. 1984. Chemical weed control in southern hardwood nurseries. South. J. Appl. For. 8(1):16–22.

7. South, D. 1988. Mechanical weed control for the forest nursery. Georgia Forestry Commission Res. Rpt. 1:1–9.

8. South, D.B. and D.H. Gjerstad. 1980. Nursery weed control with herbicides or fumigation: An economic evaluation. South. J. Appl. For. 4(1):40–45.

9. South, D.B. and D.H. Gjerstad. 1982. Postemergence control of grasses with selective herbicides in pine and hardwood seedbeds. Tree Planter's Notes 33(1):24–28.

10. South, D.B., D.H. Gjerstad and S.J. Campbell. 1980. Comparison of methyl bromide and herbicide effects on endomycorrhizal formation, seedling production, and weed control in sweet gum seedbeds. Europ. J. For. Path. 10:371–380.

11. Tucker, M.R. and R. Rhodes. 1987. Crop fertilization based on N.C. soil tests. N.C. Dept. Agric., Circular 1.

12. Warmund, M.R. 1987. Postemergence control of an oat cover crop and broadleaf weeds in direct-seeded nursery beds. HortScience 22:603–605.

Whole-Plant Response of Selected Woody Landscape Species to Uniconazole[1]

Stuart L. Warren, Frank A. Blazich and Mack Thetford[2]
Department of Horticultural Science
North Carolina State University
Raleigh, NC 27695-7609

Abstract

Uniconazole was applied as a foliar spray or medium drench to six woody landscape species: 'Sunglow' azalea; flame azalea; 'Spectabilis' forsythia; 'Compacta' holly; 'Nellie R. Stevens' holly; and mountain pieris. One hundred days after uniconazole application, leaf, stem, and top dry weight of all species, except flame azalea and mountain pieris, decreased as uniconazole concentration increased. Compared to controls, stem and leaf dry weight were reduced by uniconazole 18 to 60% and 13 to 32%, respectively, depending on species and method of application. Stem dry weight was reduced to a greater degree, compared to leaf dry weight. For all species, drench application was more effective than foliar spray in reducing leaf, stem, and top dry weight. Leaf area of 'Spectabilis' forsythia and 'Nellie R. Stevens' holly decreased with increasing rates. However, specific leaf weight was not affected. Uniconazole did not significantly affect leaf net photosynthetic rate, stomatal conductance or internal leaf CO_2 concentrations in 'Spectabilis' forsythia or 'Nellie R. Stevens' holly. No phytotoxicity was observed on any species.

Index words: growth retardant, XE-1019, Sumagic, growth regulator

Species used in this study: 'Sunglow' azalea (*Rhododendron* L. sp. 'Sunglow'); flame azalea [*Rhododendron calendulaceum* (Michx.) Torr.]; 'Spectabilis' forsythia (*Forsythia* × *intermedia* Zab. 'Spectabilis'); 'Compacta' holly (*Ilex crenata* Thunb. 'Compacta'); 'Nellie R. Stevens' holly (*Ilex* L. sp. 'Nellie R. Stevens'); and mountain pieris [*Pieris floribunda* (Pursh ex Sims) Benth & Hook].

Growth regulator used in this study: uniconazole, (E)-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol.

Significance to the Nursery Industry

Uniconazole can provide effective height control as either a drench or spray for container-grown woody landscape plants. However, uniconazole is not equally effective on all species. Specific rates and method of application should be determined based on individual species response. In this study, uniconazole produced acceptable growth reduction for four of six species tested, thus demonstrating the need to develop specific recommendations for particular species.

Introduction

Extensive pruning is required in the production and maintenance of many woody landscape plants. Until recently, use of growth retardants on woody plants remained uneconomical or produced deleterious effects (4, 6). Uniconazole and paclobutrazol have successfully suppressed growth of florist crops (2, 3, 7), fruit and nut trees (5, 11, 19), and

[1]Received for publication Nov. 30, 1990; in revised form May 28, 1991. This research was funded by the North Carolina Agricultural Research Service, Raleigh, NC 27695-7643. Technical assistance of William Reece and Dede Dubois, and financial assistance of Valent USA Corporation is gratefully acknowledged.

[2]Associate Professor, Professor, and Graduate Assistant, resp.