ifolius, allowing for its increased marketing as an insect-resistant species for landscape use.

Literature Cited

1. Bailey Hortorium. 1976. Hortus III. Macmillan Publishing Co., New York.

2. Banko, T.J. and M.A. Stefani. 1986. Effects of 5 different propagation media on rooting of Japanese and English boxwood. Proc. Southern Nurserymen's Assoc. Res. Conf. 31:212–213.

3. Dirr, M.A. 1987. Successful cutting propagation, overwintering and containerization of *Magnolia grandiflora* L. 'Bracken's Brown Beauty'. Proc. Southern Nurserymen's Assoc. Res. Conf. 31:200–203.

4. Dirr, M.A. and C.W. Heuser, Jr. 1987. The Reference Manual of Woody Plant Propagation. Varsity Press, Inc., Athens, Georgia.

5. Lewis, A.J. and E.F. Sizemore. 1978. Propagation of *Rhododendron arborescens* (Pursh) by softwood cuttings. The Plant Propagator 24(4):11–12.

6. McClintock, E. and A.T. Leiser. 1979. An Annotated Checklist of Woody Ornamental Plants of California, Oregon, & Washington. Univ. of California, Berkeley.

7. Oka, P. 1978. Propagation of *Abelia grandiflora* 'Edward Goucher'. The Plant Propagator 24(1):4–5.

8. Schultz, P.B. 1985. Evaluation of selected *Cotoneaster* spp. for resistance to hawthorn lace bug. J. Environ. Hort. 3:156–157.

9. Schultz, P.B. 1983. Evaluation of hawthorn lace bug feeding preference on *Cotoneaster* and *Pyracantha*. Environ. Entomol. 12:1808–1810.

10. Schultz, P.B. and M.A. Coffelt. 1987. Oviposition and nymphal survival of the hawthorn lace bug (Hemiptera: Tingidae) on selected species of *Cotoneaster* (Rosaceae). Environ. Entomol. 16:365–367.

11. Ticknor, R.L. and W.L. Bluhm. 1987. *Arctostaphylos columbiana* rooting trial. The Plant Propagator 24(3):11–12.

12. Tilt, K.M. and T.E. Bilderback. 1987. Physical properties of propagation media and their effect on rooting of three woody ornamentals. HortScience 22(2):245–247.

13. Wheeler, A.G., Jr. 1981. Hawthorn lace bug, first record of injury to roses, with a review of host plants. Great Lakes Entomol. 14:37–43.

Pre-forcing Treatments Influence Bud Break and Shoot Elongation in Forced Woody Species[1]

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Abstract

Experiments were conducted to evaluate the feasibility of pre-forcing treatments for the release of bud dormancy of dormant stems of lilac, privet and Vanhoutte spirea. The new softwood growth of these dormant stems was used either as explants for *in vitro* culture or as cuttings for rooting studies of woody plant species in the off-season. A pre-forcing 15% bleach solution (0.78% NaOCl) soak hastened bud break, enhanced percentage of bud break, and promoted shoot elongation. Pre-forcing wetting agent treatments produced similar results to those of the bleach soak with variation among wetting agents and plant species. Smaller treatment differences were observed in the forcing characteristics when stems were collected later in the winter, probably because the cold requirement of the buds had been completely or partially met. This technique will provide explants for *in vitro* culture and softwood cuttings for propagation of woody plants over an extended period.

Index words: pre-forcing, forcing solution, woody plants, dormancy, bud break, shoot elongation

Species used in this study: common lilac (*Syringa vulgaris* L.); privet (*Ligustrum vulgare* L.); Vanhoutte spirea (*Spiraea* × *Vanhouttei* (C. Briot) Zab.)

Significance to the Nursery Industry

Pre-forcing techniques described herein enable growers to produce new softwood growth from dormant stems of woody plant species in the off-season. This new growth can be used either as cuttings for rooting, or as explant materials for micropropagation. The technique also reduces the need for valuable greenhouse space to house stock plants, since stems to be forced can be collected in the fall and held in cold storage until needed for forcing.

Introduction

Softwood shoots are the best explant source for woody plant tissue culture (8). However, the season to obtain such new softwood growth for *in vitro* culture and rooting propagules is relatively short. Furthermore field-collected materials used as explant sources frequently have a high contamination rate. Commercial bleach solutions and wetting agent(s) have been used for many years by tissue culturists for surface disinfestation. However, there are no reports in the literature of attempts to use pre-forcing bleach soaks before forcing the tissues of woody plant species.

In our research, pre-forcing soaks were employed to disinfest the dormant woody stems before putting them into the forcing solutions to provide cleaner softwood tissues for *in vitro* culture and the rooting of softwood cuttings. The

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enhanced forcing response of stems collected in late fall and early winter has facilitated the progress of woody plant tissue culture and rooting studies (5, 8, 9). The objectives of this project were to evaluate responses of cut dormant woody stems to a pre-forcing bleach treatment, and to compare effects of different wetting agents on bud break and shoot elongation.

Materials and Methods

Stems of dormant lilac, privet and Vanhoutte spirea, 20 to 25 cm (8 to 10 in) in length, were collected at the University of Nebraska-Lincoln from October to December, 1987 and 1988. The basal third of each stem was subjected to a soak at 23°C (73°F) for 15 minutes in either 15% commercial bleach solution (0.78% NaOCl) plus 20 drops Tween-20 per liter (34 oz), or water soak and then forced in 330 ml (11 oz) forcing solution of 200 mg (0.00705 oz) 8-hydroxyquinoline citrate (8-HQC) per liter (34 oz) and 2% sucrose. In another experiment, the basal one third of each stem was soaked with the following wetting agent solutions for 15 minutes, followed by a rinse of distilled water for 3 to 4 minutes before putting them into the forcing solutions. All wetting agents, Tween 20, Trydet 20, Poe nonyl phenol, aqua-gro and ACA 160, were used at 20 drops per liter (34 oz) of water or 15% bleach solution.

Immediately following these treatments, the basal ends of the stems were then freshly cut and immersed into our standard forcing solutions for 10 days (3, 4, 6), which are similar to those used in the floriculture industry to enhance cut flower longevity (1, 2, 7). Forcing solutions employed were combinations of 200 mg (0.00705 oz) 8-hydroxyquinoline citrate (8-HQC) per liter (34 oz) and 2% sucrose with or without 10 mg (0.00035 oz) gibberellic acid (GA_3) per liter (34 oz).

The stems and the solutions (330 ml, 11 oz) were held at 23°C (73°F) under 16 hours of light per day provided by cool white fluorescent tubes at 12.8 ± 4.8 umol $sec^{-1}m^{-2}$. The stems were re-cut and the solutions completely replaced every 3 to 4 days. The experiment was a completely random design (CRD) with 12 single-stem replications for each treatment. Percent bud break (total buds per stem), days to bud break and length of shoots were recorded 10 days after the dormant stems were soaked in the solutions. Analysis of variance techniques were performed and treatment means exhibiting significant differences were separated by Duncan's multiple range test.

Results and Discussion

Buds of stems soaked in 15% bleach solutions broke 2 to 3 days earlier than those on non-soaked stems (Table 1). Bleach soak increased the percentage of bud break by up to 20% when compared with the no-soak control. Elongation of new softwood growth for the bleach treated stems was 3.0 mm (0.12 inches) greater than the stems of the no-soak control (Table 1).

The effects of a pre-forcing soak on dormancy release varied with plant species, e.g. lilac, privet, spirea. Differences between bleach soak and the water soak control were statistically significant for days to bud break, percent bud break and shoot elongation (Table 1). For Vanhoutte spirea, the water soak treatment resulted in fewer days to bud break, and a greater percentage of bud break than the bleach soak treatment. This was possibly because of tissue damage from the bleach solution or winter damage because of the thinner bud scales. Bleach soak treatments also kept stems clean in the forcing solutions. This response was typical of solutions containing bleach.

Percentage bud break was increased by the pre-forcing wetting agent treatments, with variation observed among the different wetting agents and species (Table 2). The best treatments when using water were Tween-20 or Poe Nonyl Phenol; when using wetting agents combined with 15% bleach solution, the best treatments were Tween-20 or ACA 160 for spirea; For privet, the best treatments were Tween-20 or ACA 160 plus water, or Tween-20 or Trydet 20 plus 15% bleach solution, while for lilac, Tween-20 or Aqua-gro plus water, or ACA 160 plus 15% bleach solution were found to be most successful (Table 2). Some wetting agents appeared to reduce percent bud break for privet, but data were not statistically different. The wetting agent may have enhanced contact by bleach solution to sensitive plant materials.

Bud break of Vanhoutte spirea was hastened on stems soaked with water plus some of the wetting agents, breaking 1 to 2 days earlier than those on stems soaked with water alone. However, except for Aqua-gro, a pre-forcing soak with 15% clorox bleach solution plus wetting agents delayed bud break. This is consistent with data obtained in 1987 (Table 1). The best wetting agents for accelerating bud break were Tween-20, Trydet 20, or ACA 160 plus water, or Aqua-gro plus 15% bleach solution.

Elongation of new softwood growth was also enhanced for privet when soaked with 15% bleach solution plus wetting agents (Table 3). For lilac, increases and decreases in elongation were observed among the different wetting agents relative to controls. The effects of pre-forcing soaks with bleach solution alone or with different treatments of wetting agents on bud break and shoot elongation were diminished when the stems to be forced were collected in late January and early February (data not shown). The cold requirement of these stems was probably partially or completely met (5, 9).

The mechanism by which bleach and wetting agent treatments enhance bud break is not clear. It may be that the pre-forcing treatment with bleach solution or with different

Table 1. Effects of a pre-forcing bleach soak on days to bud break, % bud break and shoot elongation of forced woody stems.

	Days to bud break		Bud break (%)		Shoot length (mm)	
Plant species	**Bleach soak**	**Water soak**	**Bleach soak**	**Water soak**	**Bleach soak**	**Water soak**
Lilac	3.5 b[z]	5.9 a	90.1 a	82.9 a	21.5 a	18.5 b
Privet	5.6 b	7.7 a	32.0 a	12.0 b	17.3 a	8.6 b
Spirea	4.8 a	3.5 b	77.5 a	81.2 a	7.9 a	6.1 b

[z]Means within rows followed by the same letter are not significantly different at the 0.05 level (Duncan's multiple range test).

Table 2. **Effect of a pre-forcing soak on % bud break of woody stems forced for 10 days (December, 1988).**

Wetting agent[z]	Bud break (%) Lilac	Privet	Spiraea
Water alone (Water control)	19.3 c[y]	35.4 c	60.0 c
Tween 20 + Water	60.2 a	56.6 b	90.9 a
Trydet 20 + Water	38.1 b	34.8 c	60.2 c
Poe nonyl phenol + Water	39.4 b	37.4 c	86.5 ab
Aqua-gro + Water	57.4 a	35.7 c	72.5 b
Aca 160 + Water	20.0 c	67.5 a	79.9 b
Bleach solution (15%) alone (Bleach control)	34.9 c	51.1 c	62.6 c
Tween 20 + Bleach solution (15%)	44.0 b	74.9 a	89.1 a
Trydet 20 + Bleach solution (15%)	44.5 b	65.4 b	71.7 b
Poe nonyl phenol + Bleach solution (15%)	35.1 c	48.7 c	72.4 b
Aqua-gro + Bleach solution (15%)	37.5 c	56.7 bc	78.3 b
Aca 160 + Bleach solution (15%)	57.3 a	60.2 b	89.7 a

[z]All wetting agents added at 20 drops per liter (34 oz) of water or bleach solution.

[y]Statistical comparisons in vertical columns applied within species for water or bleach treatments only (e.g. compare treatments 1 through 6 for lilac). Means followed by the same letter are not significantly different at the 0.05 level (Duncan's multiple range test).

Table 3. **Effects of a pre-forcing soak on shoot elongation of new softwood growth from woody stems forced for 10 days (December, 1988).**

Wetting agent[z]	Shoot length (mm) Lilac	Privet
Water alone (Water control)	17.0 c[y]	6.0 b
Tween 20 + Water	21.2 a	7.8 a
Trydet 20 + Water	18.6 b	6.7 b
Poe nonyl phenol + Water	18.9 b	5.9 b
Aqua-gro + Water	15.6 c	5.6 b
Aca 160 + Water	18.8 b	6.0 b
Bleach solution (15%) alone (Bleach control)	19.4 b	6.1 b
Tween 20 + Bleach solution (15%)	22.1 a	8.0 a
Trdet 20 + Bleach solution (15%)	20.0 b	8.1 a
Poe nonyl phenol + Bleach solution (15%)	18.5 b	8.2 a
Aqua-gro + Bleach solution (15%)	16.1 c	7.2 ab
Aca 160 + Bleach solution (15%)	23.4 a	6.8 b

[z]All wetting agents added at 20 drops/l of water or bleach solution.

[y]Statistical comparisons in vertical columns applied within species for water or bleach treatments only (e.g. compare treatments 1 through 6 for lilac).

Means followed by the same letter are not significantly different at the 0.05 level (Duncan's multiple range test).

wetting agents prevented physiological blockage of vascular tissues, thus allowing continuous uptake of water and nutrients. This may then stimulate cellular activities.

Pre-forcing soaks with bleach solution or with an appropriate wetting agent promoted the release of bud dormancy and enhanced shoot elongation of forced woody stems collected in late fall and early winter. This technique provided more softwood material in a relatively short period of time for stems collected and forced in late fall and early winter, therefore expediting research progress. Use of this forcing solution approach can also save valuable greenhouse space, reducing or eliminating the need to keep stock plants for *in vitro* studies and rooting of softwood cuttings in the off-season. Commercial nursery growers can use these forcing solution techniques to produce softwood growth which can be used as explants for *in vitro* propagation, or as cuttings for rooting, in order to reduce costs and speed up propagation. Initial pre-forcing treatments with bleach and/or wetting agents such as Tween-20, Trydet 20, or ACA 160 are recommended.

Literature Cited

1. Larsen, F.E. and J.F. Scholes. 1966. Effects of 8-hydroxyquinoline citrate, N-dimethyl amino succinamic acid and sucrose on vase-life and spike characteristic of cut snapdragons. Proc. Amer. Soc. Hort. Sci. 89:694–701.

2. Marousky, F.J. 1968. Influence of 8-hydroxyquinoline citrate and sucrose on vase-life and quality of cut gladiolus. Proc. Fla. State Hort. Soc. 81:415–419.

3. Read, P.E. and G. Yang. 1989. Responses *in vitro* of explants chemically treated via forcing solutions. Proc. Intern. Plant Prop. Soc. 38:406–408.

4. Read, P.E. and G. Yang. 1989. Influencing propagation by stock plant PGR treatments. Acta Hort. 251:121–127.

5. Read, P.E., G. Yang, and J. Yue. 1988. Effects of a pre-forcing bleach wash on bud break and shoot elongation in forced woody species. HortScience 23:825.

6. Read, P.E. and Q. Yang. 1987. Novel plant growth regulator delivery systems for *in vitro* culture of horticultural plants. Acta Hort. 212:55–59.

7. Tjia, B., F.J. Marousky, and R.H. Stamps. 1987. Response of cut gerbera flowers to fluoridated water and a floral preservative. HortScience 22:896–897.

8. Yang, G. and P.E. Read. 1989. Effects of BA, GA_3, IAA and NAA in the forcing solution on bud break and shoot elongation in forced woody stems. Proc. Plant Growth Regulator Soc. Amer. 150–155.

9. Yang, G. and P.E. Read. 1989. Pre-forcing soaks influence bud break and shoot elongation in forced woody plant species. Abstracts of 86th Ann. Meeting Amer. Soc. Hort. Sci. p139. (abst. no. 599).