Comparison of Perlite and Peat:perlite Rooting Media for Rooting Softwood Stem Cuttings in a Subirrigation System with Minimal Mist[1]

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Abstract

Perlite and mixtures of milled sphagnum peat and perlite (1:16, 1:8, and 1:4 by vol) were compared as rooting media in a propagation system utilizing subirrigation with minimal mist for rooting softwood stem cuttings of nine woody plant species. The influence of rooting medium on percentage rooting, number of roots per rooted cutting, and length of the longest roots on each cutting varied with species. Composition of the media had no effect on percentage of cuttings that rooted, number of roots per rooted cutting, or length of the longest root of 'Late Blue' highbush blueberry (*Vaccinium corymbosum* L. 'Late Blue'). Cuttings of Amur maple (*Acer ginnala* Maxim.) and 'Ruby Spice' sweet pepper bush (*Clethra alnifolia* L. 'Ruby Spice') produced the longest root in 1:4 peat:perlite, and cuttings of 'Ruby Spice' sweet pepper bush produced the greatest number of roots in 1:8 peat:perlite. Cuttings of redvein enkianthus [*Enkianthus campanulatus* (Miq.) Nichols] produced more roots in 1:8 peat:perlite than in perlite, and longer roots in 1:16 and 1:8 peat:perlite than in perlite. The number of roots per cutting of ginkgo (*Ginkgo biloba* L.) was greatest in 1:16 peat:perlite. Cuttings of Carolina silverbell (*Halesia carolina* L.) rooted in the greatest percentage in perlite, and cuttings of panicle hydrangea (*Hydrangea paniculata* Sieb.) rooted in the greatest percentages in perlite and 1:8 peat:perlite. The number of roots per cutting of 'Kwanzan' cherry and 'Shasta' doublefile viburnum [*Viburnum plicatum* Thunb.var. *tomentosum* (Thunb.) Rehd. 'Shasta'] was greatest in 1:16 and 1:8 peat:perlite. Root length per cutting of 'Kwanzan' cherry (*Prunus serrulata* Lindl. 'Kwanzan') increased with an increase in the amount of peat in the medium. Rooting medium pH decreased and moisture content increased as the amount of peat in the media increased from 1:16 to 1:8 to 1:4 (peat:perlite, by vol).

Index words: adventitious root formation, asexual plant propagation.

Species used in this study: Amur maple (*Acer ginnala* Maxim.); 'Ruby Spice' sweet pepper bush (*Clethra alnifolia* L. 'Ruby Spice'); [*Enkianthus campanulatus* (Miq.) Nichols.]; ginkgo (*Ginkgo biloba* L.); Carolina silverbell (*Halesia carolina* L.); panicle hydrangea (*Hydrangea paniculata* Sieb.); 'Kwanzan' cherry (*Prunus serrulata* Lindl. 'Kwanzan'); 'Late Blue' highbush blueberry (*Vaccinium corymbosum* L. 'Late Blue'); 'Shasta' doublefile viburnum [*Viburnum plicatum* Thunb.var. *tomentosum* (Thunb.) Rehd. 'Shasta'].

Significance to the Nursery Industry

Softwood cuttings are routinely propagated in mist, fog, or enclosed polyethylene tent systems with the goal of maintaining a positive water status in cuttings until rooting occurs. However, fog systems are expensive to install and maintain, enclosure systems are prone to excessive heat buildup, and intermittent mist can cause leaching of foliar nutrients. Subirrigation is a method of propagation that allows the rooting of cuttings with little or no use of mist. Recent studies have indicated that rooting response in subirrigation may be affected by solution pH and that subirrigation does not perform as well as mist for some species. In this study, we evaluated the propagation of nine woody plant species, from softwood cuttings, in a subirrigation system with media of perlite or three mixtures of peat and perlite. This subirrigation system also used minimal mist (10 sec every 64 min). Rooting results varied with species, but using mixtures of peat and perlite appears to be a practical method of adjusting rooting medium pH and moisture content to optimize rooting conditions for individual species.

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Introduction

Plant propagation systems such as mist, fog, and enclosed polyethylene tents are routinely used to minimize the loss of water from leafy stem cuttings by reducing the water vapor pressure gradient between the leaf tissue and the air. However, these systems are not without problems. Under mist, leaching of foliar nutrients can occur (3) leading to foliar chlorosis or necrosis, algal growth, clogged nozzles, and waterlogged media (8). Mist and fog systems can be expensive to install and maintain, and fog and enclosure systems require shading and careful monitoring to prevent excess heat buildup (8).

An alternative method of propagation uses subirrigation to maintain cutting water status instead of increasing the relative humidity of the air surrounding cuttings with mist, fog, or enclosures. A subirrigation system supplies water to the base of a cutting by capillary action through a coarse medium which is immersed in a reservoir of water maintained at a level below the base of the cutting (12, 18). Success in rooting stem cuttings of several plant species under subirrigation has been reported with *Acer* x *freemanii* E. Murray 'Indian Summer,' *A. rubrum* L. 'Autumn Flame,' *Dendranthema* x *grandiflorum* (Ramat.) Kitamura, *Fuchsia* x *hybrida* hort. Ex Vilm. 'Dollar Princess,' *Rhododendron* L. 'Catawbiense Album,' *R.* 'P.J.M.,' *R.* 'Purple Gem,' *Spiraea* x *bumalda* Burv. 'Goldflame,' *Syringa vulgaris* L. 'Charles Joly,' and *Ulmus* L. 'Pioneer' (1, 5, 9, 12, 18, 19). Inferior rooting results have been reported for other species in subirrigation, i.e. *Amalanchier lamarckii* F.G. Schroed., *Maackia amurensis* Rupr. & Maxim., *Prunus serrulata* Lindl. 'Kwanzan', and *Syringa vulgaris* L. 'Michael Buchner' (1). In the most recent work in this area, Aiello and Graves (1) concluded that woody plant taxa vary in their response to the subirrigation method of rooting cuttings.

Physical and chemical aspects of rooting media, such as pH and moisture content, can affect rooting response of stem cuttings (9, 11, 14). All successful propagation using subirrigation reported to date has used horticultural grade perlite as the rooting medium (1, 5, 9, 12, 18, 19). The pH of perlite can range from 6 to 8 (8), but peat:perlite mixtures, which are used routinely in propagation under mist or fog, have a pH of less than 5 (9). It has been demonstrated that the pH of root initiation media affects auxin uptake in microcuttings of apple (*Malus domestica* Borkh.) (6). Lee *et al*. (10) found that pretreating the bases of stem cuttings with either 2 N acid (H_2SO_4) or base (NaOH, pH 10.5) influenced rooting on cuttings of certain species. Moisture content also varies between perlite and peat:perlite combinations, and recommendations for the proportions of peat and perlite in a rooting medium vary with propagation system and season (11, 14).

Softwood stem cuttings of nine woody ornamental plant species were evaluated in this study. Cuttings of these species are routinely propagated under mist or fog by using peat:perlite (1:1 by vol) (2). The objective of this research was to propagate softwood stem cuttings in a subirrigation system to evaluate the effect of varying the peat content of peat:perlite rooting media on rooting. Perlite or peat:perlite mixtures of 1:16, 1:8, or 1:4 (by vol) were evaluated. Subirrigation was supplemented with minimal mist (10 sec every 64 min) because preliminary trials indicated that softwood and herbaceous cuttings could become water stressed in subirrigation alone.

Materials and Methods

Softwood terminal stem cuttings of Amur maple, 'Ruby Spice' sweet pepper bush, redvein enkianthus, ginkgo, Carolina silverbell, panicle hydrangea, 'Kwanzan' cherry, 'Late Blue' highbush blueberry, and 'Shasta' doublefile viburnum were collected from field-grown plants on the University of Rhode Island (URI) campus and at the URI Agricultural Experiment Station East Farm, both in Kingston, RI (41° 29' N, 71° 31' W). Collection dates were varied to optimize the condition of the cutting wood. In the summer of 1998, cuttings of 'Ruby Spice' sweet pepper bush were taken on June 29, Amur maple and Carolina silverbell on July 1, 'Late Blue' highbush blueberry on July 2, 'Kwanzan' cherry on July 3, ginkgo and redvein enkianthus on July 14, 'Shasta' doublefile viburnum on August 5, and panicle hydrangea on August 6. All cuttings were trimmed to 10–12.5 cm (4–5 in) and held in polyethylene bags at 4.4C (40F) for 12 to 24 hrs before being prepared for insertion in the rooting medium.

Cuttings of 'Ruby Spice' sweet pepper bush, Amur maple, Carolina silverbell, ginkgo, 'Shasta' doublefile viburnum, and panicle hydrangea were not wounded before insertion in rooting media. Cuttings of 'Late Blue' highbush blueberry, 'Kwanzan' cherry, and redvein enkianthus were wounded on one side of the cutting base by making a shallow, 2.5 cm (1 in) long, slice with a sharp knife. Cuttings of 'Ruby Spice' sweet pepper bush were treated with 0.1% 1 *H*-indole-3-butyric acid (IBA), (Hormodin No. 1, E.C. Geiger, Inc., Harleysville, PA); cuttings of Carolina silverbell were treated with 0.3% IBA (Hormodin No. 2); cuttings of Amur maple, 'Kwanzan' cherry, redvein enkianthus, 'Shasta' doublefile viburnum, and hydrangea were treated with 0.8% IBA (Hormodin No. 3); and cuttings of 'Late Blue' highbush blueberry and ginkgo were treated with 4.5% IBA (Hormex 45, Brooker Chemical Corp., North Hollywood, CA). The base of each cutting was inserted to a depth of approximately 1.3 cm (0.5 in) in a talc preparation of each hormone.

The subirrigation system with minimal mist consisted of a reservoir of water [1.4 m (4.7 ft) × 3.5 m (11.3 ft) × 10 cm (3.9 in)] lined with 6 mil (1.4 mm, 0.06 in) black polyethylene plastic placed over a level bed of sand in a greenhouse bench. Plastic flats [53 cm (20.9 in) × 38 cm (15 in) × 9.5 cm (3.7 in); Kadon Corp., Dayton, OH] were filled with super coarse perlite (Whittemore Company Inc., Lawrence, MA) or a mixture of milled sphagnum Canadian peat (Maximilian Lerner Corp., New York, NY) and perlite in ratios of 1:16, 1:8 or 1:4 (by vol). Cuttings were inserted approximately 5.1 cm (2 in) deep in the media and arranged randomly in rows within each flat. Water in the subirrigation reservoir was maintained at a depth of 5.1 cm (2 in) by refilling with tap water twice weekly as needed. Mist was applied for 10 sec every 64 min.

The greenhouse in which the propagation system was maintained was covered with an inflated double layer of 4 mil polyethylene and shaded with a single layer of Chicopee cloth (50% shade; Lumite, Gainesville, GA). The greenhouse thermostats were set to activate the heating system at 18C (65F) and ventilation fans at 24C (75F). Temperatures in the propagation area averaged 23 ± 4C (74F) day and 22 ± 4C (71F) night [range 19C (66F) to 34C (90F)], relative humidity averaged 84 ± 11% [range 54 to 96%; measured using a CS500 temperature and relative humidity probe (Campbell Scientific, Logan UT)]. Peak irradiance, recorded between noon and 1:00 PM, averaged 91 $\mu mol \cdot m^{-2} \cdot s^{-1}$ [range 35 to 124 $\mu mol \cdot m^{-2} \cdot s^{-1}$, measured using a Li-Cor LI-190SB quantum sensor (Li-Cor, Lincoln, NE)].

Each treatment (perlite, peat:perlite 1:16, 1:8, and 1:4 by vol) was evaluated using four replicate flats, each containing a row of 10 cuttings (samples) of each species, for a total of 40 cuttings of each species per treatment. Cuttings of each of the nine species were placed in rows in flats, with the position of the rows randomly assigned throughout the course of the experiment. The sixteen flats were arranged in the subirrigation reservoir in a completely randomized design. Cuttings of 'Ruby Spice' sweet pepper bush were harvested on July 29, Amur maple and Carolina silverbell on July 30, 'Kwanzan' cherry on July 31, 'Late Blue' highbush blueberry on August 20, 'Shasta' doublefile viburnum on August 21, panicle hydrangea on August 26, ginkgo on September 9, and redvein enkianthus on September 18. Rooted cuttings were removed carefully from the rooting medium and the roots rinsed in tap water to remove excess peat or perlite. The percentage of cuttings that rooted, the number of roots per rooted cutting, and the length of the longest root per rooted cutting were recorded. Cuttings were considered rooted if they possessed one or more roots > 1 mm (0.04 in) in length.

Measurements of pH of the media were made at the start and end of the experiments. Equal volumes of each rooting medium and distilled water (90 ml each) were combined, stirred, and allowed to stand for 30 min. The mixture was strained, and the pH of the solution was measured using an

Accumet model 1002 pH meter (Fisher Scientific, Pittsburgh, PA). The volumetric moisture fraction ($m^3 \cdot m^{-3}$) of each medium was measured on September 14 using changes in the apparent dielectric constant (ThetaProbe, type ML1; Theta Meter, type HH1; Delta Devices, Cambridge, England). Because the probe could not be inserted easily into the rooting medium, samples of each medium were placed in Classic Pan nursery containers [20 cm (7.9 in) × 13 cm (5.1 in); Nursery Supplies, Inc., Tustin, CA], and the containers held on a greenhouse bench at container capacity for 24 hrs before moisture content measurements were made. Moisture readings were indicative of differences in moisture retention among the four media, and may have differed from the actual moisture content of the media in the flats during the experiment.

Data for each species were analyzed using ANOVA and treatment means were compared with Duncan's multiple range test (16). Percentage data were arcsine transformed before analysis.

Results and Discussion

Rooting medium pH decreased and moisture content increased as the amount of peat increased from 1:0 to 1:16, 1:8, and 1:4 mixtures of peat:perlite (by vol) (Table 1). Rooting media pH increased over the course of the experiment (Table 1) while moisture content did not vary significantly over the experiment (data not presented).

Improved rooting on cuttings of several species (redvein enkianthus, ginkgo, 'Kwanzan' cherry, and 'Shasta' doublefile viburnum) in peat:perlite rooting media as compared with perlite may have been due to lowered pH or increased moisture content. The number of roots per rooted cutting of redvein enkianthus was twice as great in a 1:8 mixture of peat to perlite than in perlite alone, and the length of the longest root was greater in 1:16 and 1:8 peat:perlite mixtures than in perlite alone (Table 2). Cuttings of ginkgo produced more roots in a 1:16 peat:perlite mixture than in a 1:8 or 1:4 mixture or in perlite alone. The length of the longest root on each rooted cutting of 'Kwanzan' cherry increased as the amount of peat in the rooting medium increased. A highest number of roots per rooted cutting of 'Kwanzan' cherry and 'Shasta' doublefile viburnum in a 1:16 or 1:8 mixture of peat to perlite as compared with perlite or a 1:4 mixture of peat with perlite indicates that an acidic yet well aerated rooting medium is favorable for rooting these species.

Cuttings of Carolina silverbell and panicle hydrangea rooted in higher percentages in perlite than in a 1:4 peat:perlite mixture. For cuttings of both species, neither of these treatments differed from 1:16 or 1:8 mixtures of peat to perlite, which both possessed a low pH, suggesting that the more optimal availability of water in perlite or the overabundance of water in a 1:4 peat:perlite mixture probably influenced rooting more than pH. Cuttings of Amur maple developed longer roots in 1:4 peat:perlite than in 1:16 peat:perlite. This was probably due to the high moisture content of the 1:4 mixture rather than low pH because all mixtures of peat and perlite used in this experiment had a low pH.

Cuttings of 'Ruby Spice' sweet pepper bush rooted in high percentages regardless of treatment. The number of roots per rooted cutting was higher in perlite than in any other treatment, but the length of the longest root on each cutting was longer in the 1:4 than the 1:16 or 1:8 mixtures of peat and perlite. Longest root length in perlite did not vary from that in the other treatments.

For cuttings of 'Late Blue' highbush blueberry, percentage rooting, the number of roots per rooted cutting, and the length of the longest root on each cutting did not vary in response to treatment.

Perlite has been used exclusively as the rooting medium in previous studies evaluating stem cutting propagation in subirrigation systems (1, 5, 9, 12, 18, 19). Holt *et al.* (9) attempted to root cuttings of *Rhododendron* 'P.J.M.' and *Ilex* x *meserveae* S.Y. Hu in a subirrigation system using mixtures of peat and perlite in ratios of 1:5 and 1:10 (by vol), but noted inferior results. Stem rot occurred, and it was presumed that too much water was held by the media. The present research demonstrates that mixtures of peat and perlite can be used successfully as a rooting medium in a subirrigation system with minimal mist. However, rooting response varies by species.

Other researchers have reported improved rooting of cuttings under acidic conditions. Holt *et al.* (9) rooted cuttings of *Rhododendron* 'P.J.M.,' *R.* 'Catawbiense Album,' and *R.* 'Purple Gem' in a subirrigation system provided with water of high (7.5) or low (4.5) pH. Rooting percentages and root volume displacement were recorded, and it was found that rooting improved for all cultivars when a low pH subirrigation solution was used (9). Harbage and Stimart (6) rooted microcuttings of apple (*Malus domestica* Borkh.) and found that, at a low concentration of IBA, more roots developed on microcuttings rooted in a medium of pH 5.5 than pH 7.0. Other research by Harbage *et al.* (7) demonstrated that pH affects IBA uptake but not metabolism in microcuttings of 'Gala' and 'Triple Red Delicious' apple (*Malus domestica* Borkh. 'Gala' and 'Triple Red Delicious'). However, Lee *et al.* (10) found that pretreating stem cuttings with acid increased rooting of some species while pretreating with base increased rooting of others.

Rooting may be improved at a low pH because of increased auxin uptake by the cutting. Crown gall suspension tissue culture cells have been used to show that auxin enters a cell by both a saturable carrier and by passive diffusion (15). Passive diffusion of protonated auxin into cells continues after the carrier mechanism becomes saturated, if extracellular pH is below that of the cytoplasm. The addition of peat to a perlite rooting medium lowers pH, and rooting may be

Table 1. Volumetric moisture fraction and pH of perlite and peat:perlite mixes (1:16, 1:8, and 1:4, by vol) used as rooting media in subirrigation, and the pH of tap water used in the subirrigation reservoir.

Rooting medium	pH Start	pH End	Volumetric moisture fraction ($m^3 \cdot m^{-3}$)
Perlite	7.1[z]	7.3	26.1 ±1.7[y]
Peat:perlite 1:16	5.0	5.6	29.5 ±1.5
Peat:perlite 1:8	4.9	5.2	33.0 ±1.4
Peat:perlite 1:4	4.4	4.6	34.8 ±1.1
Tap water	7.1	7.4	

[z]pH measurements are the mean of three samples. Standard deviation in all cases ≤ 0.1 units.

[y]Moisture contents are the mean of four samples ± S.D. Values presented as ($m^3 \cdot m^{-3} \times 100$).

Table 2. **Percentage rooting, root number, and root length of cuttings of nine species propagated in perlite and peat:perlite (1:16, 1:8, and 1:4, by vol) in subirrigation with minimal mist (10 sec every 64 min). Means are the average of four experimental units.**

Species and dependent variable	Date of sticking (1998)	Rooting time (days)	Treatment			
				Peat:perlite		
			Perlite	1:16	1:8	1:4
Acer ginnala	7/1	29				
Percentage rooting			25a[z]	28a	48a	35a
Roots per rooted cutting			10a	7a	12a	15a
Length of longest root (mm)			68ab	54b	59ab	78a
Clethra alnifolia 'Ruby Spice'	7/1	28				
Percentage rooting			100a	98a	100a	90a
Roots per rooted cutting			20a	12c	16b	14bc
Length of longest root (mm)			30ab	23b	29b	32a
Enkianthus campanulatus	7/14	66				
Percentage rooting			63a	63a	55a	68a
Roots per rooted cutting			5b	7ab	10a	8ab
Length of longest root (mm)			8b	11a	11a	9ab
Ginkgo biloba	7/14	57				
Percentage rooting			55a	40a	23a	35a
Roots per rooted cutting			5b	11a	6b	7b
Length of longest root (mm)			15a	19a	16a	19a
Halesia carolina	7/1	29				
Percentage rooting			45a	25ab	25ab	5b
Roots per rooted cutting			17a	11a	10a	15a
Length of longest root (mm)			8a	7a	10a	14a
Hydrangea paniculata	8/6	20				
Percentage rooting			90a	80ab	93a	73b
Roots per rooted cutting			122a	130a	109a	116a
Length of longest root (mm)			28a	28a	32a	33a
Prunus serrulata 'Kwanzan'	7/3	28				
Percentage rooting			88a	95a	95a	100a
Roots per rooted cutting			64b	94a	87a	65b
Length of longest root (mm)			25d	33c	47b	56a
Vaccinium corymbosum 'Late Blue'	7/2	49				
Percentage rooting			18a	10a	20a	25a
Roots per rooted cutting			11a	13a	8a	9a
Length of longest root (mm)			11a	14a	20a	25a
Viburnum plicatum var. *tomentosum* 'Shasta'	8/5	16				
Percentage rooting			98a	100a	98a	95a
Roots per rooted cutting			59b	66a	76a	55b
Length of longest root (mm)			13a	14a	16a	15a

[z]Means separation within species and rooting parameter by Duncan's multiple range test, $P \leq 0.05$.

improved in a medium of peat and perlite over perlite alone if the cutting of the species being propagated is pH sensitive due to uptake of auxin or if auxin is a limiting factor.

The moisture content of the rooting medium can affect the water status of the cutting and influence rooting. Grange and Loach (4) used stem cuttings of *Skimmia rogersii* hort. to evaluate the availability of water in perlite and peat:perlite (1:1 by vol) rooting media. Water uptake by cuttings increased in direct proportion to water content. In freshly made cuttings, substantially greater water uptake occurred in perlite than peat:perlite. However, after 7-days, the difference in uptake continued, but it was not as great. Loach (11) used summer softwood cuttings of *Fuchsia magellanica* Lam. 'Nana Gracilis,' to evaluate rooting in mixtures of peat and grit (1:3, 1:1, and 3:1 by vol), held at 12 different water contents, to show that the rooting of cuttings increased with increased medium moisture content. However, the importance of balancing water content and aeration of the rooting medium was shown when the reverse relationship was seen under winter conditions with harder cuttings, which rooted better in a drier media.

While perlite is an inert material with little or no cation exchange and buffering capacity (8, 17), milled sphagnum peat is highly complex and varies in composition with origin (8, 13). The physical properties of peat depend primarily on its degree of decomposition, while its chemical properties depend on its botanical origin (13). It is possible that characteristics other than pH and moisture content influenced root initiation and development on stem cuttings in rooting media comprised of peat and perlite during the present study.

Results of this study indicate that mixtures of peat and perlite can be used successfully as a rooting medium to root softwood cuttings of many woody species in a system of subirrigation with minimal mist, and that varying the ratio of peat to perlite can be a practical means of adjusting the pH and moisture content of the rooting media. The ability to manipulate these factors may be critical to a plant propagator who is attempting to root cuttings of plant species which might be sensitive to the pH or moisture content of the rooting medium.

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