

## Evaluating the Role of pH in the Rooting of Cuttings: Eastern Region, North America Research Grant Paper<sup>®</sup>

Brian K. Maynard

Department of Plant Sciences, University of Rhode Island, Kingston, Rhode Island  
02881 U.S.A.

### INTRODUCTION

**The Importance of Soil pH in Horticulture.** It is generally accepted that conditions of optimal soil pH exist for individual plant species, and that tolerances vary among species and families. In particular, plants which grow well on acidic soils, also known as acidophilic or calcifugous plants, not only tend to become chlorotic at high soil pH due to iron (Fe) or manganese (Mn) deficiency, but also can tolerate excess Fe, Mn, and aluminum (Al) ions in the soil solution of acidic soil. More common are plants that are sensitive to free Al ions at low soil pH, and are able to sequester and take up the bound forms of Fe and Mn at higher soil pH, known as calcicolous plants. Other plants, called amphitolerant, can tolerate a wide range of soil pH (e.g., 3.5 to 8.5). Very little research has been done on woody ornamental plants to evaluate the precise limits or mechanisms of tolerance to soil acidity or alkalinity. In practice, horticulturists develop working lists of plants best adapted to various soil types.

**The Importance of Media and Water in Propagation.** Rooting medium provides support for stem cuttings and supplies water and oxygen to cuttings during rooting (Hartmann et al., 1997). Physical and chemical attributes of the rooting medium can dramatically affect rooting response of stem cuttings (Loach, 1985). And yet, of all the edaphic factors influencing the rooting of stem cuttings in plant propagation, medium pH is probably the least well understood. Medium components such as peat, sand, and perlite are used in various combinations to optimize water holding capacity, aeration, and root growth without knowledge or appreciation of their effect on medium pH.

**Propagation Studies Evaluating pH Effects on Adventitious Root Formation.** Relatively little information is available on the role of pH in the rooting of cuttings. Lee et al. (1976) found that pretreating the bases of stem cuttings with either 2N acid ( $H_2SO_4$ ) or base (NaOH, pH 10.5) influenced rooting on cuttings of certain species, and in general acid treatment improved the rooting of calcicolous (lime-loving) species, while base treatment favored calcifugous (acid-loving) species. Recent physiology studies by Harbage and Stimart (1996) on the rooting of apple (*Malus domestica* Borkh.) microcuttings found that as the pH of the root initiation medium decreased, lower concentrations of IBA were required to increase the number of roots initiated per cutting. Further research (Harbage and Stimart, 1998) concluded that pH affects IBA uptake but not metabolism in microcuttings of 'Gala' and 'Triple Red Delicious' apple.

Holt et al. (1998) used treatments of sulfuric acid or a sphagnum peat slurry to lower the pH of the subirrigation solution to 4.5. Cuttings of *Rhododendron*

'Catawbiense Album', P.J.M. Group, and 'Purple Gem' rooted in these treatments rooted in higher percentages and produced more root than those rooted in a perlite-tap water control (pH 7.5). However, the sulfuric acid treatment may be impractical for many plant propagators, and the peat slurry treatment promotes excessive evaporation of water from the subirrigation reservoir. The same researchers conducted a separate experiment using perlite and peat rooting media (5 : 1, v/v) and (10 : 1, v/v) with poor results. It was presumed that the media held too much water, causing stem rot. However, perlite and peat (1 : 1, v/v) is routinely used with success to root cuttings under mist.

The objective of this research was to evaluate, using a practical approach, the effect of varying medium pH on the rooting of a wide variety of softwood and hardwood stem cuttings. The justification for this research lies in the lack of knowledge available to the plant propagator on how pH affects rooting, both in terms of designing better rooting media, and how pH effects differ among plant species. We present here our experience with altering peat and perlite ratios for the propagation of stem cuttings of 'Blue Girl' holly (*Ilex x meserveae* 'Blue Girl') in a subirrigation system.

## MATERIALS AND METHODS

Terminal cuttings of Blue Girl holly were collected on the University of Rhode Island campus in early March, trimmed to 8 to 10 cm, and stripped of leaves on the lower 5 cm of the stem. A 2.5-cm slice wound was made on one side of the stem and the basal 1.5 cm of the base was dipped for 5 sec in a 1:5 aqueous dilution of Dip 'n Grow™ (1.0% 1H-indole-3-butyric acid, 0.5% 1-naphthalene acetic acid, Astoria-Pacific, Clackamas, Oregon) before insertion in the propagation medium.

The subirrigation system utilized 4.0 L Classic Pan nursery containers (20 cm × 13 cm; Nursery Supplies, Inc., Tustin, California) filled to a depth of 11 cm with either supercoarse horticultural-grade perlite (Whittemore Company Inc., Lawrence, Massachusetts) or a mixture of milled sphagnum Canadian peat (Maximilian Lerner Corp., New York, New York) and perlite (1 : 16, 1 : 8, or 1 : 4, v/v). Four nursery containers of the same rooting medium were placed in separate plastic flats (53 cm × 38 cm × 9.5 cm; Kadon Corp., Dayton, Ohio) lacking drainage holes. A single drainage hole was drilled 5 cm above the bottom on each side to maintain a reservoir of water at that depth. Each nursery container contained 10 stem cuttings inserted 5 cm deep into the rooting medium so that the cutting base did not contact the water reservoir.

Medium pH was recorded using an Accumet model 1002 pH meter (Fisher Scientific, Pittsburgh, Pennsylvania) at the time of sticking and harvesting cuttings (March 3 and March 31, respectively). The moisture content of each medium mixture (m<sup>3</sup> water m<sup>3</sup> soil) was measured once, midway through the rooting period, using a Theta Probe, type ML1, and Theta Meter, type HH1, (Delta Devices, Cambridge, England). 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, Georgia). The greenhouse thermostats were set to maintain a mean temperature of 22°C.

Each treatment consisted of four experimental units (nursery containers in flats) and ten samples (cuttings) per experimental unit. Treatments were placed on a greenhouse bench in a completely randomized design. On 31 March cuttings were harvested, and percentage of cuttings which rooted was recorded. A cutting was considered rooted if it developed one or more roots >3 mm in length. Rooted cuttings

were rinsed in water to remove excess rooting medium and the number of roots per cutting and the length of the longest root on each cutting were recorded. Statistical analyses were performed with the PROC GLM procedure (SAS Inc., 1985) to determine if media components affected rooting results. Data were analyzed using ANOVA, and treatment means compared with Duncan's multiple range test. Percentage data were arcsine transformed before analysis.

## RESULTS AND DISCUSSION

Perlite is an inert material with little or no cation exchange or buffering capacity (Hartmann et al., 1997). Horticultural grade peat moss varies considerably in its composition depending upon its botanical origin (Sheard, 1975). Chemical properties such as acidity are determined by the botanical origin of the peat, while physical properties such as moisture-holding capacity are determined by the degree of decomposition of the peat (Puustijarvi and Robertson, 1975).

All cuttings remained turgid from sticking through harvest and showed no signs of nutrient stress. Cuttings rooted in high percentages across all treatments (Table 1). The average number of roots per rooted cutting and the length of the longest root per rooted cutting were significantly greater in a 1 : 4 mixture of peat and perlite than in perlite or the 1 : 16 and 1 : 8 mixtures of peat and perlite. The number of roots per rooted cutting also was significantly greater in 1 : 16 and 1 : 8 peat and perlite than in perlite alone. The length of the longest root on cuttings rooted in 1 : 16 and 1 : 8 mixtures of peat and perlite did not vary significantly from each other, but were significantly greater than that of perlite alone.

**Table 1.** Percentage rooting, root number, and root length of cuttings of *Ilex xmeserveae* 'Blue Girl' rooted in perlite or peat and perlite (1 : 16, 1 : 8, and 1 : 4, by volume) in subirrigation without mist. Cuttings collected 3 March 1998, rooting time was 28 days.

	Treatment			
	Perlite	Peat and perlite		
		1 : 16	1 : 8	1 : 4
Rooting percentage <sup>z</sup>	95 a <sup>y</sup>	93 a	98 a	100 a
Root number	26 d	57 b	49 c	64 a
Length of longest root (mm)	8 c	14 b	13 b	15 a

<sup>z</sup> Means are the average of four replicate subirrigation systems containing 10 cuttings each (40 cuttings per treatment).

<sup>y</sup> Means separation within row and rooting parameter by Duncan's multiple range test,  $P \leq 0.05$ .

Most previous reports of success using subirrigation as a means of propagating stem cuttings utilized perlite alone as the rooting medium (Aiello and Graves, 1998; Graves and Zhang, 1996; Holt et al., 1998; Mezitt, 1978; Zhang and Graves, 1995). One study which used peat and perlite mixtures as the rooting media reported poor rooting results due to stem rot, and although data was not presented, it was presumed that excess water was held by the rooting medium (Holt et al., 1998). The present research demonstrates that Blue Girl holly not only can be rooted satisfactorily using peat and perlite mixtures as the rooting media in a subirrigation system, but rooting is even better than when rooted in perlite alone.

Rooting medium pH decreased with an increase in the proportion of peat from 1 : 16 to 1 : 8 to 1 : 4 (v/v) (Table 2), and increased slightly over the course of the experiment. Decreasing rooting medium pH corresponded with improved rooting of Blue Girl holly. An explanation for why pH may affect auxin uptake was proposed by Rubery and Shelldrake (1974). They used crown gall suspension tissue culture cells to show that auxin enters a cell by a saturable carrier and by passive diffusion. If extracellular pH is below that of the cytoplasm, passive diffusion of auxin, in the protonated form, into cells continues even after the carrier mechanism becomes saturated, allowing for greater uptake of exogenous root-promoting substance. This was confirmed by Harbage and Stimart's (1998) work with apple microcuttings.

Grange and Loach (1983) demonstrated the availability of water from perlite and peat and perlite (1 : 1, v/v) media to fresh and 7-day old stem cuttings of *Skimmia rogersii*. In all cases water uptake increased in direct proportion to medium moisture content. In fresh cuttings, substantially greater water uptake occurred from perlite alone than peat and perlite at any given water content. After 7 days, however, the difference in uptake between perlite and peat and perlite was not as great and, in practice, the peat and perlite medium reached a higher water content than perlite alone, allowing for greater water uptake by cuttings.

**Table 2.** Moisture content and pH of perlite and peat and perlite mixes (1 : 16, 1 : 8, and 1 : 4, v/v) used as rooting media in subirrigation, and the pH of tap water used in the subirrigation reservoir.

Rooting medium	pH		Moisture content (%)
	3/3/98	3/31/98	
Perlite	7.1 <sup>z</sup>	8.1	26.1+1.7 <sup>y</sup>
Peat : perlite (1 : 16)	5.0	5.3	29.5+1.5
Peat : perlite (1 : 8)	4.9	4.9	33.0+1.4
Peat : perlite (1 : 4)	4.4	4.4	34.8+1.1
Tap water	7.1	7.4	

<sup>z</sup> pH measurements are the mean of three samples. Standard deviation <0.1 units.

<sup>y</sup> Moisture contents are the mean of four samples + S.D. Values presented as (m<sup>3</sup> m<sup>-3</sup> × 100).

Loach (1985) observed that rooting of cuttings in a system such as an enclosure, which does not maintain wet foliage, improved when the water content of the rooting medium was increased. Adding peat to a perlite medium was recommended as a means of increasing rooting medium water content. This concept also may hold true for subirrigation. In the present experiment, moisture content increased in proportion to the amount of peat to perlite in the mix (Table 2), as would be predicted from the work of Grange and Loach (1983). Increased rooting also was observed as the amount of peat in the media increased, suggesting that the higher moisture content of the peat-containing media may also have benefitted root initiation and elongation.

This study took a practical approach to determining the effect of perlite and peat and perlite media on rooting of stem cuttings of Blue Girl holly in a subirrigation system. The effects observed could be due to medium moisture content, pH, or other physical or chemical properties of perlite and peat, but demonstrate that peat and perlite media in the range of 1 : 16 and 1 : 4 are satisfactory, and even superior to the use of perlite alone as a subirrigation rooting medium. Further studies will evaluate the rooting of this and other species in subirrigation systems using buffered perlite, which will allow control of medium pH without the confounding factor of medium moisture content.

#### LITERATURE CITED

- Aiello, A.S. and W.R. Graves.** 1998. Success varies when using subirrigation instead of mist to root softwood cuttings of woody taxa. *J. Environ. Hort.* 16:42-47.
- Grange, R.I. and K. Loach.** 1983. Environmental factors affecting water loss from leafy cuttings in different propagation systems. *J. Hort. Sci.* 58:1-7.
- Graves, W.R. and H. Zhang.** 1996. Relative water content and rooting of subirrigated stem cuttings in four environments without mist. *HortScience* 31:866-868.
- Harbage, J.F. and D.P. Stimart.** 1996. Effect of pH and 1H-indole-3-butyric acid (IBA) on rooting of apple microcuttings. *J. Amer. Soc. Hort. Sci.* 121:1049-1053.
- Harbage, J.F., D.P. Stimart, and C. Auer.** 1998. pH affects 1H-indole-3-butyric acid uptake but not metabolism during the initiation phase of adventitious root induction in apple microcuttings. *J. Amer. Soc. Hort. Sci.* 123:6-10.
- Hartmann, H.T., D.E. Kester, F.T. Davies, Jr., and R.L. Geneve.** 1997. *Plant propagation principles and practices*. 6th ed. Prentice Hall, Upper Saddle River, New Jersey.
- Holt, T.A., B.K. Maynard, and W.A. Johnson.** 1998. Low pH enhances rooting of stem cuttings of rhododendron in subirrigation. *J. Environ. Hort.* 16:4-7.
- Lee, C.I., J.L. Paul, and W.P. Hackett.** 1976. Root promotion on stem cuttings of several ornamental plant species by acid or base pretreatment. *Comb. Proc. Intl. Plant Prop. Soc.* 26:95-99.
- Loach, K.** 1985. Rooting of cuttings in relation to the propagation medium. *Comb. Proc. Intl. Plant Prop. Soc.* 35:473-485.
- Mezitt, E.V.** 1978. Propagation by cuttings of lilacs and other hard-to-root species by the sub-irrigation method. *Comb. Proc. Intl. Plant Prop. Soc.* 28:494-496.
- Puustjarvi, V. and R.A. Robertson.** 1975. Physical and chemical properties, p. 23-38. In: Robinson, D.W. and J.G.D. Lamb (eds.). *Peat in Horticulture*. Academic Press, London.
- Rubery, P.H. and A.R. Sheldrake.** 1974. Carrier-mediated auxin transport. *Planta (Berl.)* 118:101-121.

- SAS Institute.** 1985. SAS User's Guide: Statistics. 5th ed. SAS Institute Inc., Cary, North Carolina.
- Sheard, G.F.** 1975. Loamless substrates for use in containers and as unit products, p. 119-132. In: Robinson, D.W. And J.G.D. Lamb (eds.). Peat in horticulture. Academic Press, London.
- Zhang, H. and W.R. Graves.** 1995. Subirrigation to root stem cuttings: Comparison to intermittent mist and influence of fertilization. HortTechnology 5:265-268.

---

## Ideas from the Scandinavian Propagator's Exchange®

### Bill Barnes

Lorax Farms, 2319 Evergreen Ave., Warrington, Pennsylvania 18976 U.S.A.

In 1999 I was the lucky recipient of the Eastern Region, North America I.P.P.S. exchange propagator to the Scandinavian Region. It was a memorable trip and my wife and I saw a great deal of horticulture.

Denmark was the choice of the Scandinavian Region for their 1999 meeting and that was the ultimate destination. However, fortune was in our favor and we had an opportunity to fly to The Netherlands first and then proceed onto Denmark. This was a choice that was planned and should a future recipient have the opportunity I would highly recommend a stopover in Holland.

While not much time was allotted for the Holland excursion, having only one day, I opted to go to the TROPENBERG Arboretum in Rotterdam. For those interested in North American natives this is a must stop as it represents one of the finest collections of North American plants that I have seen. Much can be learned from going to the Arboretum and admiring the work of Professor Van Hoey Smith.

Traveling by train, my wife and I made our way to Denmark, through the countryside of Holland and then Germany. Train travel in Europe is an excellent way to travel and much can be seen and learned from observation from the train cars. We traveled well into the night to the nursery of Anton Thompsen to the upper northern part of the country near the North Sea.

Anton was our first host and a most gracious and kind man. His nursery is known in local vernacular as Thompsen Plant Skole. Anton was born in the U.S.A. and speaks impeccable English. He knows a lot about U.S.A. horticulture and brought back to Denmark some of the skills he learned in the U.S.A. He really has two nurseries, a full service retail garden center and a wholesale nursery. The nurseries grow and offer a large range of plant material to meet customer demands and they are specialists in the production of *Chamaecyparis lawsoniana*, *Ilex aquifolium* cultivars, and woody hydrangea.

They propagate many of their own field liners in very modern up-to-date greenhouses equipped with mist, bottom heat, and supplemental lighting. They grow the liners on in 2-liter pots in outdoor beds surrounded by windscreens of *Sorbus* and *Thuja*. Once these plants are rooted they are moved to the field to be grown as finished plants.

Anton pointed out to me that he works closely with the Danish Institute of Horticultural Science and is always on the lookout for new and improved material.