Using Subirrigation to Root Stem Cuttings: A Project Review

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INTRODUCTION

As propagators, we were fascinated by the possibility of rooting cuttings without mist (Zhang and Graves, 1995) Subirrigation is a alternate method of propagation that can reduce labor costs and water use, (Wen-fei, et al , 1998) while promoting healthy cuttings with rooting percentages equivalent to mist Rooting cuttings without mist would help prevent water-logging of the rooting medium, eliminate dripping mist lines, and reduce disease We thought that one of the greatest advantages to the subirrigation system would be in managing the cuttings Multiple varieties of cuttings could be placed within a single propagation area The cuttings would use water as needed and therefore avoid the problems associated with controlling mist. In addition, using subirrigation to root stem cuttings may be an alternative method for approaching difficult-to-root cuttings (Mezitt, 1978) Since we were unable to find any literature based on studies in a northwest climate, we began a 4-year study to see if subirrigation propagation would work in the North Willamette Valley

The subirrigation method we used for the project consisted of a large (14 inches × 20 inches × 4 inches), sturdy tray without drainage holes made by Dyna-Tray. Two, 5⁄32-inch drainage holes were drilled on opposite ends of each tray, 1 inch up from the bottom The tray was filled with rooting medium, and the water reservoir was maintained by hand watering one to three times a week Each individual tray was used as a treatment replicate Although we used several experimental designs, we always replicated each treatment four times with a minimum of 84 cuttings (240 maximum) per treatment

Stem cuttings were collected from several sources and were usually used within 6 h The maximum amount of time we would store the cuttings (40°F, 80% relative humidity) was 24 h. To prepare the cuttings, we soaked them in water for 30 min, then made a fresh cut and stripped off the lower leaves. All of the stem cuttings were dipped for about 10 sec in a solution of Dip N' Grow The concentration of rooting hormone varied depending on softness or hardness of the cutting. The stem cuttings were stuck in the trays about 1 inch into the medium so that they would be about 1.5 inches above the water level

The propagation greenhouse used for the study was located at the North Willamette Research and Extension Center, Aurora, Oregon It is a small (18 ft × 40 ft), double polyethylene structure recently renovated to improve the control of mist and bottom heat. Even with shading (47%), the air temperature was difficult to control and the weekly mean high temperatures during the summer approached 90°F. A small exhaust fan helped cool the air temperature but also lowered the relative humidity by bringing in drier air

METHODS AND RESULTS

Experiment 1. In 1995, to evaluate subirrigation as a method to root cuttings, we compared it to mist propagation We attempted to root about 20,000 cuttings from 19 diverse woody plants One-half of the cuttings was stuck in perlite and the other half in pumice We used a solar-input mist controller (Davis Engineering) to manage the intermittent mist Under this system mist frequency changed automatically based on bright or cloudy days. Generally, we felt our misted cuttings were not over-watered.

Our results from this initial study showed that eight of the nineteen plants we tested rooted "well" with subirrigation when compared to the misted controls Another six of the plants rooted "fair," while only *Acer*, *Rhododendron*, and *Magnolia* cuttings were rated as "poor." Overall, the type of rooting medium (perlite or pumice) did not have a major effect on rooting. We observed that many of the softwood cuttings would wilt immediately and some of the leaves burned in a matter of days (*Acer*, *Berberis*, and *Prunus*) Consequently, rooting was reduced compared to the misted cuttings. The misting of cuttings helps to maintain the water status of the cutting (foliar absorption) and reduce leaf temperatures (evaporative cooling)

Experiment 2. We were convinced that subirrigation could be used instead of mist to root woody stem cuttings of certain plants. Therefore, one of our goals in 1996, was to improve rooting percentages of cuttings propagated by subirrigation Softwood and semihardwood stem cuttings of *Berberis thunbergii* 'Atropurpurea Nana' (syn 'Crimson Pigmy'), *Cotinus coggygria* 'Royal Purple', *Daphne ×burkwoodii* 'Carol Mackie' were stuck in perlite under subirrigation every 3 to 4 weeks until August. Fall and winter propagation was conducted with hardwood cuttings of *Chamaecyparis nootkatensis* 'Pendula', *Picea glauca* var *albertiana* 'Conica', *Pieris japonica* 'Variegata', and *Rhododendron* 'The Hon Jean Marie de Montague'. A total of 600cuttings per plant was used for each sticking The propagation treatments consisted of covering the cuttings to reduce light and increase the relative humidity around the cutting The greenhouse was divided into three sections. One of the sections was covered with shade cloth (47%) which was suspended 0.7 m above the trays and the cloth draped over the ends of the bench creating sidewalls Within another section a lightweight spun-bonded polyester row cover (Reemay, Dupont) was laid directly above the cuttings. The last section was left uncovered and became the control treatment Six trays (30 cuttings per variety, per tray) were placed under each treatment and served as replicates. The treatments were also split in half by a fertilizer treatment. A nutrient solution of Peter's Liquid Feed 20N-20P-20K (100 ppm N) was used as the subirrigation water source for one-half of the cuttings, while the other half received only well water.

Experiment 3. In 1997, our attention turned to propagating stem cuttings of herbaceous perennials In the 1995 study, *Lavandula stoechas* var. *lusitanica* rooted at 81% under subirrigation with no stem or root rot during propagation. Beginning 2 July through 13 Aug., about 15,000 softwood cuttings were collected from plants considered to be difficult-to-root. The cuttings were prepared and placed under the following propagation treatments: (1) subirrigation in trays; (2) subirrigation in trays with 4-day mist, (3) mist propagation in standard propagation trays; (4) mist propagation in subirrigation trays, (5) subirrigation in cells under fog,

(6) subirrigation in trays under fog; (7) subirrigation in trays, no fog; (8) cells within subirrigation trays, no fog. The propagation media used for all treatments was perlite and peat (9 : 1, v/v). The treatments were replicated four times. After 6 to 10 weeks the cuttings were lifted and evaluated for rooting.

Cuttings from several of the plants rooted just as well under subirrigation as they did under mist or fog. Specific plants such as *Arctostaphylos* 'Alaska', *Cistus salvifolius*, *Eupatorium purpureum* var. *maculatum* 'Atropurpurem', and *Phlox paniculata* 'Franz Schubert' rooted best under one or more of the subirrigation treatments when compared to either mist or fog. While *Campanula carpatica* 'Karl Foerster' and *Geranium* 'Lawrence Trayman' did not root well under any of the treatments, only *Iberis sempervirens* 'Alexanders White' did not respond very well to subirrigation propagation. There were no treatment effects on the rooting of *Helianthemum* 'Raspberry Ripple', and *Rubus pentalobus* (syn. *calycinoides*) which all rooted at 80% or above. The best overall subirrigation treatment was subirrigation in trays with 4-day mist. Our earlier study with woody plants suggested that this initial mist period helped maintain the water status of the cutting resulting in higher rooting percentages. *Dendranthema weyrichii* 'White Bomb' (Syn. *Chrysanthemum weyrichii* 'White Bomb') and *Deutzia crenata* var. *nakaiana* 'Nikko' (syn. *D. gracilis* 'Nikko') rooted the best under subirrigation in fog.

Student Intern Experiments. In 1997 and 1998, student interns under our direction conducted three studies involving subirrigation propagation. These studies investigated subirrigation techniques applied to *Cotinus coggygria* 'Royal Purple' and *Daphne* ×*burkwoodii* 'Carol Mackie' and the influence of water quality on rooting. Although *Daphne* cuttings rooted best in the perlite medium, the cuttings had a higher amount of leaf browning and drop when compared to those in the perlite plus peat medium. There was large variability in successful rooting of *C. coggygria* 'Royal Purple'. Stem cuttings of *Eupatorium*, *Thyme*, *Phlox*, and *Deutzia* rooted in subirrigation trays showed a range of response to various waters. The elements found most often in water sources that influence rooting were bicarbonates, sodium, chloride, boron, and sulfur. Water pH and electrical conductivity are also important factors.

CUTTING PROPAGATION SUMMARY

***Acer rubrum* Autumn Flame® red maple.** Softwood cuttings taken in July rooted poorly in subirrigation. Rooting percentages were somewhat better using perlite as opposed to pumice as the rooting media. Stems seemed to desiccate quickly.

***Acer rubrum* 'Franksred', Red Sunset® red maple.** Semi-hardwood cuttings taken in June rooted poorly in subirrigation. Perlite was the better rooting media over pumice. Stems desiccated quickly.

***Arabis alpina* subsp. *caucasica* 'Variegata'.** Soft tip cuttings taken in August rooted poorly under subirrigation as well as in fog. Cuttings in subirrigation rooted better with four initial days of mist, although cuttings kept under mist the entire time had the highest rooting percentages. Cuttings in cells uniformly did poorly.

***Arctostaphylos* 'Alaska'.** Softwood cuttings taken in July consistently did poorly under subirrigation, mist, and fog. The one exception was the cuttings in cells; these cuttings showed the highest rooting percentages.

***Berberis thunbergii* 'Rose Glow'.** Softwood cuttings stuck in August rooted fairly well under subirrigation, although the initial occurrence of desiccation and leaf drop was deceptive. No significant difference showed up between the use of perlite or pumice as the rooting media.Cuttings placed under Reemay covers rooted somewhat better than cuttings under shade cloth or those left in the open.

***Betula utilis* var. *jacquemontii*.** A June sticking of softwood cuttings placed in subirrigation and mist rooted equally well by both methods. Pumice worked better than perlite for rooting *Betula*.

***Campanula carpatica* 'Karl Foerster'.** Soft tip cuttings stuck in July did poorly regardless if they were placed under subirrigation, mist, or fog. It made no difference whether trays or cells were used.

***Campanula lactiflora* 'Loddon Anna'.** A July sticking of soft tip cuttings placed in trays under subirrigation and mist rooted equally well and slightly better than cuttings placed in fog. Except under fog, cuttings rooted very poorly in cells.

***Campanula* 'Birch Hybrid'.** Soft tip cuttings taken in September rooted at 99% under subirrigation.

***Chamaecyparis nootkatensis* 'Pendula'.** Cuttings in subirrigation stuck on various dates over a 3-year period showed great rooting variability from low numbers up to over 70%. Cuttings fared equally well in subirrigation and mist. The rooting media (pumice, perlite or a perlite/peat combination) did not show significant differences in rooting nor did the use of coverings improve rooting.

***Dendranthema weyrichii* 'White Bomb' (syn. *Chrysanthemum weyrichii* 'White Bomb').** Cuttings taken in July rooted well under fog, mist and subirrigation. Cuttings placed in cells rooted at comparable rates.

***Cistus* 'Elma'.** Cuttings taken in August rooted equally well under subirrigation, mist, and fog. The rooting percentage of cuttings in cells lagged a little behind the cuttings in trays.

***Cistus salviifolius*.** The highest rooting percentage for *Cistus* (97%) occurred in subirrigation trays with an initial 4 days of mist. Even without the mist, the subirrigation trays rooted better than the mist or fog trays. Cell trays did not root as well under any of the systems. In the water quality studies, *Cistus* showed some sensitivity to water differences.

***Clematis* 'Etoile Violet'.** Semi-hardwood cuttings taken in June rooted equally well in subirrigation and mist trays, and tested in both systems, the pumice was the better rooting media over perlite.

***Cotinus coggygria* 'Royal Purple'.** Variability in rooting *Cotinus* indicated that there might be anarrow window for rooting this plant. Heal cuttings taken in May rooted equally well in subirrigation and under mist. Soft tips in subirrigation trays easily wilted, but this did not reduce overall rooting. Cuttings taken later dropped significantly in their rooting percentages. Adding shading or Reemay cloth did not improve rooting. Cuttings rooted equally well in pumice and perlite.

***Cotinus coggygria* 'Velvet Cloak'.** A single sticking of softwood cuttings taken in June rooted at poor rates in subirrigation. The use of coverings did not improve the rooting results.

***Daphne* ×*burkwoodii* 'Carol Mackie'.** Semihardwood cuttings taken in August rooted fairly well in both subirrigation and mist. Cuttings did better in a medium of straight perlite, as opposed to a peat/perlite combination or pumice alone. Shade cloth did not improve rooting; Reemay over the trays actually lowered rooting percentages.

***Deutzia crenata* var. *nakaiana* 'Nikko' (syn. *D. gracilis* 'Nikko').** Soft tip cuttings stuck in August rooted well under all three methods of propagation. The highest rooting percentages were produced under fog. However, mist and subirrigation rooted at high rates as well. Cuttings rooted in cells with no difficulty either.

***Erica cinerea* 'Atropurpurea'.** Semi-hardwood cuttings taken in October rooted well in subirrigation and at a higher percentage than under mist. Rooting was higher under perlite than pumice.

***Eupatorium purpureum* subsp. *maculatum* 'Atropurpureum'.** Summer soft tip cuttings suffered some leaf desiccation initially in subirrigation, but cuttings ended up rooting well and at higher percentages than those cuttings under mist or fog. Subirrigation cuttings also put on new vigorous growth by the time they were evaluated. Cuttings placed in cells rooted equally as well as cuttings in trays.

Geranium 'Lawrence Trayman' (*G. cinereum* × *G. argenteum*). Soft tip cuttings taken in July rooted poorly under subirrigation and fog and only slightly better under mist.

***Gypsophila paniculata* 'Bristol Fairy'.** Soft tip cuttings taken in September rooted at 90% under subirrigation.

***Helianthenum* 'Raspberry Ripple'.** Summer, soft, tip cuttings rooted at high percentages under subirrigation, mist and fog. Cuttings in cells under all three systems rooted at slightly lower but still acceptable rates.

***Helianthemum* 'Rhodanthe Carneum' (syn. *H. nummularium* 'Wisley Pink').** Soft tip cuttings taken in September rooted well in subirrigation, but showed sensitivity to water quality.

***Hypericum androsaemum* 'Glacier'.** Semihardwood cuttings stuck in October rooted at 100% both under subirrigation and in mist.

***Iberis sempervirens* 'Alexander's White'.** Softwood cuttings taken in July rooted poorly in subirrigation and fog and well below rooting percentages under mist.

***Juniperus scopulorum* 'Medora'.** Hardwood cuttings taken in January rooted poorly under all treatments (less than 10%). No real difference in the use of perlite or pumice as the rooting media was apparent.

***Juniperus squamata* 'Blue Star'.** Semihardwood cuttings taken in October rooted equally well in subirrigation as under mist (about 80%). Some stem rot occurred after 2 weeks in propagation. There was no difference in rooting rates between perlite or pumice used as the rooting media.

***Lavandula stoechas* var. *lusitanica*.** Semi-hardwood cuttings taken in October rooted around 80% under subirrigation and mist.

***Magnolia kobus* var. *stellata* 'Royal Purple'.** Softwood cuttings propagated in June rooted better under mist than subirrigation. There was no clear difference in the use of pumice or perlite as the rooting media.

***Myrica pensylvanica*.** Softwood cuttings taken in August rooted only somewhat better under mist than subirrigation. Both only rated in a fair range of rooting percentages despite heavy callusing. Cuttings rooted better in a rooting media of pumice rather than perlite.

***Pelargonium ×hortorum*.** Softwood cuttings rooted at close to 100% in subirrigation with minimal desiccation from *Botrytis*.

***Phlox paniulata* 'Franz Schubert'.** Soft tip cuttings rooted well under subirrigation — in fact, better than under mist or fog. When cuttings were placed in cells for rooting, they did not root nearly so well in subirrigation but fared considerably better in mist and fog.

***Phlox paniculata* 'David'.** Soft tip cuttings taken in September rooted at close to 100% in subirrigation, but also showed sensitivity to water quality.

***Picea glauca* var. *albertiana* 'Conica'.** January hardwood cuttings rooted with only fair results under subirrigation. Better rooting results occurred in December the following year with no improvement brought by using shade or reemay coverings. A peat/perlite media provided betterrooting results than perlite or pumice alone.

***Pieris japonica* 'Variegata'.** Semihardwood cuttings rooted from fair to good in subirrigation, depending on the year. Perlite worked better than pumice as the rooting media. The use of shading and reemay did not improve rooting.

***Prunus ×cistena*.** Softwood cuttings taken in August rooted in subirrigation with only fair results; rooting under mist was higher for *Prunus* cuttings (66% as opposed to 85% rooting). The use of pumice or perlite did not seem to improve the results.

***Rhododendron* 'The Hon. Jean Marie de Montague'.** Attempts to root September hardwood cuttings of 'The Hon. Jean Marie de Montague' were unsuccessful in subirrigation. The cuttings formed heavy callus but rooted poorly in both peat and peat/perlite mixes. Coverings did not improve the rooting results.

***Rhododendron* 'Vulcan'.** Similar results to *R*. 'The Hon. Jean Marie de Montague' under the growing conditions at the NWREC.

***Ribes aureum*.** Softwood cuttings taken in July rooted better under mist than subirrigation and fog. Cells in subirrigation trays did poorer still.

***Rosa* 'John Davis'.** Semihardwood cuttings taken in August rooted well in subirrigation and mist. Loss of some lower leaves did not affect rooting results. Both perlite and pumice were used for rooting media with identical results.

***Rubus pentalobus* (syn. *R. calycinoides*).** Softwood cuttings rooted in July at almost 100% in subirrigation, fog, and mist. Cuttings in cells rooted just as consistently.

***Saponaria ocymoides* 'Alba'.** Soft tip cuttings taken in July rooted poorly in both subirrigation and fog but did somewhat better under mist. Cells placed in subirrigation trays rooted at even lower rates.

***Saponaria* ×*olivana*.** Soft tip cuttings taken in August rooted poorly in subirrigation, mist, and fog. Cell trays containing cuttings placed in fog and mist did only slightly better at rooting.

***Saxifraga* ×*urbium* (syn. *S. umbrosa* 'London Pride').** Small tip cuttings taken in July rooted well in subirrigation as well as under mist and fog.

***Brachyglottis* (Dunedin Group) 'Sunshine' (syn. *Senecio grayii*).** Tip cuttings stuck in August rooted fairly well in mist and fog and slightly less effectively under subirrigation. There was some indication that water quality may have influenced rooting percentages.

***Thymus* ×*citriodorus* 'Argenteus' (syn. *T. argenteus*).** Soft tip cuttings taken in August and September rooted close to 100% under subirrigation and mist, but considerably less in fog. *Thymus* in propagation appeared sensitive to water quality. Both perlite and peat/perlite combinations worked well as propagation media.

***Thymus* 'Doone Valley'.** Soft tip cuttings started in July rooted well in subirrigation but at lower rates in fog and mist. These studies first indicated that *Thymus* was sensitive to water quality. Cuttings placed in cells did worse than cuttings rooted in trays.

***Viburnum opulus* 'Roseum' (syn. *V. opulus* 'Sterile').** Softwood cuttings taken in May rooted fairly well and at comparable rates under subirrigation and mist. There was less incidence of foliar disease in subirrigation trays than for those under mist.

***Viburnum trilobum* 'Wentworth' (syn. *V.* 'Triwentworth').** Softwood cuttings taken in May rooted well in subirrigation and mist. Foliar diseases developed at equally high rates among cuttings under both systems. However, rooting rates remained fairly high (around 80%).

***Vinca minor* 'La Grave' (syn. 'Bowles').** Soft tip cuttings taken in July rooted fairly well in subirrigation. The addition of 4 days under mist raised rooting percentages to about the same rooting levels as for mist and fog. Cuttings placed in cells rooted about the same. However, cuttings placed in cells inside of subirrigation trays and then set under a mist system rooted at higher rates than in trays alone.

DISCUSSION

Water uptake by an unrooted cutting takes place through the cut stem base or through the leaves and stem. Foliar uptake of water helps in part to maintain the water balance of cuttings, but may not be the major factor for most plants (Loach, 1988). A good example of this was demonstrated by softwood cuttings of *Betula*. These cuttings recover from wilting immediately after they are stuck in subirrigation trays, while the cuttings in the misted trays remain wilted for days. One explanation for this observation is that wilted leaves can absorb water, but very little of that water is conducted to the stems. Water uptake through a cut stem of a cutting increases as the moisture content of the rooting medium increases. Also, water

uptake by wounded cuttings is improved due to more cut stem contact with the medium. The constant moisture level of the subirrigated trays could have favored stem water uptake.

Successful rooting of stem cuttings under subirrigation is influenced by the same factors that influence the rooting of cuttings under mist propagation. The timing when the cuttings are stuck is a major concern for both types of propagation. *Daphne* appears to be a good candidate for rooting under subirrigation and the best rooting occurred mid-June regardless of the treatments, except for those cuttings that received fertilizer. It appears that a more mature stem cutting of some woody plants root better than very soft cuttings. The first group of *Berberis* cuttings performed the worst with rooting seen only in the shaded treatment. Soft cuttings will lose water more rapidly than mature wood. As leaf temperatures increase so does water loss, especially leafy stem cuttings under bright sunlight conditions. Although some improvements with the shading and row cover treatments were seen at times, they were not consistent. *Chamaecyparis* rooted best under full light conditions. In addition, we found that using a nutrient solution as the water source in subirrigation was very detrimental to rooting of the cuttings. Regardless of plant, stick date, or environmental conditions, cuttings that received fertilizer in the irrigation water rooted very poorly with rooting percentages less than 10%.

Soft tip cuttings placed under subirrigation may at first seem to go through a period of decline. Appearances can be deceptive. For instance, cuttings of *Eupatorium* after initial desiccation on the leaf edges, turned around by evaluation time, put on new growth and in fact rooted at higher percentages than mist or fog.

CONCLUSION

It is our belief that subirrigation propagation is an alternative method to root stem cuttings of many woody and herbaceous perennial plants. In some cases, supplemental mist or using fog with subirrigation is of benefit. We also found evidence that water quality is a very important factor in using subirrigation to root cuttings. In addition, cuttings under subirrigation propagation usually developed strong healthy root systems.

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