drainage and root formation. We incorporate just enough additional perlite each year to level the benches before sticking.

A drench of Dexon and Terrachlor at recommended rates is applied each year before cuttings are stuck in this mix. Since we do not replace this medium each year, the one-time replacement cost could be spread over approximately 5 years of useage, which makes the cost per cutting insignificant. We stick about 200,000 evergreen cuttings in this mix each year. Genera rooted in this medium are: *Chamaecyparis*, *Juniperus*, *Thuja*, and *Taxus*.

To summarize the media discussed above provide us with the necessary variations to accommodate the specific needs of the many genera of plants we are rooting. It is obvious from these figures that the number of cuttings stuck in each medium and/or the number of times the medium can be used will directly affect the unit or cost per cutting for each mix.

IMPORTANCE OF PROPER AERATION IN SOFTWOOD CUTTING PROPAGATION MEDIA

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I would like to share some observations I have made at Zelenka Nursery over the past several years as our propagation medium has evolved. Several years ago, the basic requirements of a medium were that it be inexpensive and reusable, as long as no major problems occurred. Our system originally consisted of ground beds under poly, using coarse sand as a medium. At that time, we were sticking about 750,000 softwood cuttings per year and space was not a problem. To reuse the beds the next year, we would mix in some perlite and fumigate. This system gave us acceptable results until we ran out of room to expand. Each year since 1979, our softwood rooting propagation has increased by an average of 750,000 cuttings per year. Therefore, a method had to be developed to increase our production in the same amount of space. We adopted a heavy plastic flat, figuring to get at least two crops of cuttings rooted under the existing mist lines. However, the weight of the flats with the sand medium was a major problem. Each flat weighed over 90 pounds, which made careful handling almost impossible. I also observed that the rooting medium in a flat held more water than in a bed, and this aggravated latent problems always associated with cuttings propagation. To correct these problems, we started using an organic mix of rice hulls, hardwood bark, and sand. This was a green mix that had been stockpiled for only one year. Since we grow the cuttings in the same medium they are rooted in, it has to have the capacity to hold nutrients available to the plants for growth. The green mix provided the drainage we needed but tied up the nutrients. This required us to start fertilizing at 600 ppm nitrogen using a 15-0-5 liquid fertilizer. The organic mix showed promise if the culture problems could be worked out. The following year we had to use a range of greenhouses that previously hadn't been used for cutting propagation. In the polyhouses the flats were set on the ground, but the compacted ground in the greenhouses did not give acceptable drainage. In addition, the porosity was about half that of the previous year when the medium was used the second year. No doubt, the fertilizer used the year before accelerated decomposition of the mix. For the next two years we tried to maintain a uniform medium; however, we were unable to start out with the same medium from one year to the next. In order to keep it uniform, we finally switched to a perlite-based medium. We mixed in ground reed/sedge peat for cation exchange capacity and to improve water retention.

To test porosity, we used a simple test taken from the book, *Nursery Management* by Davidson and Mecklenburg (1). We fill a 64 ounce coffee can with the mix to be tested and slowly added water until the moisture glistened on top. The amount of water used gives the pore volume of the mix. Hence, the porosity can be calculated as follows:

$$\text{porosity} = \frac{\text{pore volume of mix}}{\text{container volume}} \times 100\%$$

We simply punched holes in the plastic lid of the can and poured the free water into a measuring cup. This amount of water represents the aeration pore volume in the mix. Aeration porosity can be calculated as follows:

$$\text{aeration porosity} = \frac{\text{aeration pore volume}}{\text{container volume}} \times 100\%$$

Water-retention porosity is the difference between porosity and aeration porosity; therefore:

$$\text{water retention porosity} = \text{porosity} - \text{aeration porosity}$$

A few years ago, I made the incorrect assumption that aeration and water retention were relatively equal. If the medium was holding too much water under intermittent mist, I thought that decreasing the amount of water would increase the amount of aeration. However, cuttings without roots can die without enough air before the medium dries out sufficiently to give the aeration needed for rooting. The medium is at field capacity when all the gravitational water has drained out. The next critical step is the wilt point. That is when the medium holds the water tighter than the roots can pull it away. When unrooted cuttings are sitting in media at field capacity, and there is twice as much water as air, problems can develop. For example, our sand medium has an average of 30% total porosity, but 20% is water retention and 10% is aeration. I found that knowing the total porosity but without knowing the ratio of water-retention to aeration does not help. Our organic mix had a high total porosity but the variability was in the ratio of water retention to aeration from batch to batch. When deciding what perlite mix to use, I tested three combinations of perlite and reed/sedge peat and used our organic mix as the control. The porosity percentages are shown in Table 1. We ran the same amount of mist as needed by the cuttings. The rooting percentages were all about the same but the quality of the cuttings varied substantially.

Table 1. Water-retention porosity, aeration porosity, and total porosity of various media.

Media	Total porosity (percent)	Water-retention porosity (percent)	Aeration porosity (percent)
Sand	31	20	11
50% perlite and 50% peat	43	21	22
70% perlite and 30% peat	51	17	34
90% perlite and 10% peat	53	14	39
Organic mix[1]	65	10	55

[1] 40% rice hulls, 40% wood chips, 10% sand, 10% Michigan peat.

The organic mix gave us excellent heavy rooting but, because of the green matter, very little nitrogen was available to the plant and there was not any top growth. The 90/10 mix also produced excellent roots but required more fertilizer to produce the shoot growth that the 70/30 and 50/50 mixes had. In comparing the ratios of water retention to aeration porosities, I found for our operation a ratio of 1:1 to 1:3 of water-retention porosity to aeration porosity gave us the best compromise for rooting and subsequent growth of the cuttings. While more water retention is acceptable with fast rooting cuttings, slower rooting cuttings benefit from greater aeration.

In summary, from my observations, a well-aerated medium is much more forgiving than a poorly aerated one. We have found that with three times more air than water in a mix, we can stick as many as 25% more cuttings per flat than with a water to air ratio of 1:1. However, the cuttings become too crowded if allowed to grow at that density. Root initials form faster and develop with more secondary rooting in a medium with greater aeration. This is possible most of the time because you can use a higher concentration of hormone with less basal burn than in a low aerated medium.

Our requirements for a propagation medium have changed over the years. the proper ratio of water to air porosity, cation exchange capacity, pH, weight, and improved quality and quantity of cuttings rooted, will usually offset the higher initial cost of a medium.

LITERATURE CITED

1. Davidson, H. and R. Mecklenburg. 1981. Nursery Management. Prentice-Hall, Englewood Cliffs, New Jersey.

Thursday Afternoon, December 12, 1985

The Thursday afternoon session convened at 1:30 p.m. with Mark Bridgen serving as moderator.

HOW DOES TISSUE CULTURE BENEFIT THE PRACTICAL PLANT PROPAGATOR?

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How does tissue culture benefit the *practical* plant propagator? A practical plant propagator might ask, is tissue culture propagation (i.e., micropropagation, or *in vitro* propagation) appropriate for my operation? If so, to what extent? How does a propagator determine whether to use tissue culture methods or not? What are the options? Which methods should be employed and on what species? These and numerous related questions need to be asked by the propagator who is considering tissue culture as a possible propagation method. In answering these questions it is important to remember how the practical plant propagator determines whether to use any practice,