cuttings a most satisfactory method. This technique should be used on a lot more deciduous plant materials.

REMINISCENCE ABOUT THE PAST

When I attended my first Plant Propagators Meeting it was held in Cleveland and I have only missed a few meetings since. That was twenty years or more ago. There was Case Hoogendorn, Martin Van Hoff, Leslie Hancock, Roy Nordine, Vince Bailey, and many others who became my good friends. And yes, even Bill Snyder was there, but we all looked a little different then.

I believe this is my last meeting. They tell me at the nursery that "I'm being put out to pasture," after having grown and sold plants commercially for over 50 years. Florence and I plan on an active retirement in Cass County, Minnesota, where it is beautiful, green and cool.

PETER DEL TREDICI: What about taking root cuttings early in the spring before growth and planting them out immediately to avoid some of the pretreatments? I grew *Comptonia peregrina* both ways with equal success.

RICHARD CROSS: It probably would be fine but it does not fit our schedule

VOICE: My dad did *Rhus* propagation and he always said it was important to dry them after cutting. Did you say you did that?

RICHARD CROSS: We do not dry them. However, putting them in moss in the greenhouse at 50°F probably does that.

PROPAGATING DWARF CITRUS WITH HYDRONIC RADIANT HEATED BENCHES

DONALD F. DILLON

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At Four Winds we produce over 30 citrus cultivars which are useful to the home gardener for their fruit production, their beauty as an evergreen, and for their flavors and aromas. Cultivars are chosen to ripen at many different times of the year, offering the home owner a great variety in choices.

Our trees are produced by a method called twig-grafting, developed originally by Halma and Frolick at UCLA a good many years ago. The details of our production methods, our history and our greenhouse operations are covered in an earlier paper at a Western Region meeting in San Dimas in October of 1962. At this time we'll attempt only to give a brief review of things that have occurred from 1962 to the present date, and some changes that we have found necessary. Our production involves the use of fresh new twigs — those that first appear from the spring flush and are hardened off to the point where we begin our work in May or June. Cuttings are taken from both scion and understock mother plants and brought into a propagation room which we attempt to maintain in a condition of at least kitchen cleanliness. The plant material of course is highly susceptible to infection by various pathogens while it's in process and until such time as it has been rooted and the graft healed. The scions and understocks are each prepared with a long sloping cut without a tongue. The scion and understock are then matched up and fastened together with a single strand of rubber band. From this point on the two mated pieces are handled as through they were a single cutting. These cuttings are stuck in flats containing vermiculite, the coarsest grade possible. We use a rooting hormone roughly equivalent to Hormodin #3.

Due to the fact that the scion has no contact with the rooting medium, it is, of course, necessary to produce the plants in conditions of extremely high humidity until callus has sealed the graft union. We use a Monarch fog nozzle F 110 C-2.0-120° under 125 pounds pressure which produces roughly 2.2 gallons of fine mist per hour if allowed to run continuously. Our misting period will run from 7 to 15 seconds at time intervals from 1½ to 5 minutes. The heads are located above the benches in such a fashion that when they are not in operation any drip falls free and clear of the flats below and drops into the aisle The mist produced creates a fog which completely fills the house between mistings. It is not our intent to really irrigate the understocks and the rooting medium, merely to keep the humidity as high as possible. Nevertheless, a substantial amount of moisture does accumulate in the flats and in the room, and conditions are overall quite wet.

Our source for bottom heat, which we consider essential to swift rooting, has for 25 years been provided through electric heating cables in benches. With heat we get roots, without it we don't, even after 4 weeks in the same mist house. We learned through one of our more sensitive employees whenever we had an electrical short she complained about getting a mild shock as she stuck the twig grafts in the flat. When we checked with a voltage meter, we registered 3 or 4 volts in the leaves. With 220 volts and the wet conditions, I have been concerned over the years that someone was going to get hurt sooner or later, even though the house was safety checked by a competent electrician each year. The electric heating cable worked more or less satisfactorily but we decided some changes were in order in 1979

Bruce Usury, president of the Western Region of IPPS and vice-president of propagation and production at Monrovia Nursery in Azusa, California, in a report to the California Association of Nurserymen refresher course, which was reprinted in *American Nurseryman* in September 1, 1981, showed that, in their experiences with electric heating cables, that while they were relatively inexpensive and easy to install, they did corrode and break easily. After about 5 years only about half of their system would still work. Our experience has been much the same.

In the course of a Society field trip in 1977, we observed ground beds complete with hot circulating water in CPVC plastic pipes through a bed filled with scoria. We understand, however, that the plastic pipe can expand 12 to 18 inches over a 100 foot length and that it is necessary to keep the top of the bed loaded with flats to avoid having it pop up out of the lava rock. The beds were equipped, as well, with mist heads. The entire operation was conducted out-of-doors rather than in an enclosed greenhouse. We were intrigued by it, but felt that our situation, requiring the retention of high humidity for the benefit of the scion, would necessitate that we continue with production inside a greenhouse. Additionally, ground benches seemed to lend themselves to being walked on, and a strong chance to spread disease. We believed that we should continue with benches.

Our inquiries led us to another large grower in northern California where indoor benches of concrete using polyethylene tubing to circulate hot water were being used. We were satisfied that this was the way we should go. A contractor gave us some preliminary cost estimates. Frankly, they were staggering We inquired what cost so much and he said, "After all, you're attempting to grow plants on a raised bench with concrete and copper tubing. The benches should last 30 or 40 years and therefore should be quite inexpensive in the long run". We inquired whether or not it might be possible to eliminate the copper and use CPVC or polyethylene tubing as a conduit for the hot water in the benches He looked me squarely in the eye and said, "If you want to use that stuff, get somebody else. Those materials are bound to deteriorate over a period of time and we simply won't guarantee the job." Needless to say, we proceeded following his direction and paid the price.

In January, 1979, we started work. Our first effort was to create concrete walks inside an existing greenhouse. Having completed that, we proceeded to build legs for the benches. After much deliberation we finally settled on the individual masonry blocks. We're fortunate in having a manufacturer of these blocks nearby and were able to acquire blocks that were "seconds" at a very reasonable price Their only defect seemed to be that they were slightly off color. Each leg is built from four 8″×5″×8″ blocks. We set two legs every four feet. The legs cost $1.12 per sq ft of bench.

The next big problem was how to hold the wet concrete in place after it was poured until it set up The only solution seemed to be to use plywood. We finally settled on ¾″ exterior ply This added another $0.36/sq ft of bench — total $1.48 for legs and bench bottom This added $1,776 00 to the cost of a modest area of 1200 sq ft of benches. We believe we have more than recovered the cost through relatively disease-free production after only 3 years The benches should last 15 to 20 years. We've talked to a number of people trying to learn how it might be possible to remove the plywood for re-use as we developed additional benches. No one seemed to have a good suggestion so we decided to just simply leave it there, figuring that in time even if it rotted out, the benches would still be intact Our conractor designed the system and supplied the material. The whole installation was accomplished by our own work force. The tubes are approximately 9″ apart. There are four ¾″ tubes running in the bench which is 36 feet long.

We poured the cement using a concrete pump, figuring that it was a lot easier to pump in the concrete rather than to carry it in wheelbarrows, etc.

The top of the bench is 27 inches above the walk. They are 4½ inches thick along the aisle, sloping to 3½ inches thick at the rear of the bench to allow surplus water to drain away from the walk.

We built ten benches — each 120 sq ft. Each bench has its own thermostat and zone control valve. No energy is being used where the slab is holding its temperature. We can vary the temperature for different rootstocks or turn them off completely when hardening off.

The benches, together with the prorated share of the boiler, built by A.O. Smith with 160,000 btu's — cost, then, $3.94 per sq ft. We believe that a boiler this size would be able to accommodate at least 40 such benches, inasmuch as not all of them are on at the same time because of the long heat retention of the concrete. In order to raise the temperature of 1 cubic foot of concrete 1°F it takes aproximately 32 btu. Our system is capable of raising each bench 4°F per hour at a flow rate of 1 gallon per minute. This allows maximum heat exchange to the concrete.

Between each crop the benches are given a thorough coat of copper naphthenate which works great. We have tried spraying it on with a Hudson sprayer but this causes too much vapor

Our twig grafts were stuck in fumigated flats on November 4, 1981. By November 24, 1981, we find more than half of them had two or more roots of 1 to 1½ inches in length. We expect that they will be well rooted and healed (80 to 85%) in 6 to 10 weeks and be ready to be hardened off before planting directly into a one-gallon container.

As mentioned earlier, Monrovia Nursery had built their new beds in early 1981. Theirs is a magnificent propagation facility on the ground In all, it occupies approximately 2½ acres. Each of their beds is approximately 14×110 feet long They have ½″ copper pipe spaced in each bed at 9″ intervals. The hot water is pumped at 2 gpm (twice our 1 gpm), because of the long length of the bed It enters at 110°F and exits 110 feet away, having lost 2°F, at 108°F. They attempt to maintain a temperature in the flats of about 72°F. Each of these beds are 1540 sq ft, and can hold approximately 800 flats or 178,000 cuttings. Each bed cost them $5,314 to install which, exclusive of their mist system, amounts to about $3 per square foot. This is only about 3¢ per cutting on just one crop The important point seems to be that under their previous propagation methods their results varied from about a 50 to 55% success rate to, up now to, 70 to 75% with the plants now growing uniformly and free of disease. In contrast to our tiny little water heater, producing 160,000 btu, Monrovia has two 150-horsepower boilers which produce 5,021,250 btu each Of course, these supply hot water to their new 2½-acre propagation beds in addition to their greenhouses

All of us who use mist in greenhouses generally have problems with algae build-ups on walks and on the benches. I had observed blue color on the walks at Monrovia and had inquired what treatment they were using. The answer was copper sulfate. I decided to deal with our problem in much the same way and applied copper sulfate — just a wettable powder — at the rate of about 1 lb per 30 square feet which I simply spread with a broom, making sort of a slurry with the moisture on the walks. I can report that our walks turned a lovely blue and after five months there is no apparent algae build-up thus far. I have no idea how long it will be before retreatment will be necessary. I similarly treated adjoining walks with Consan at the rate of 10 oz/gal. These walks required retreatment in approximately three weeks. They now have been treated with copper sulfate and it appears to be holding up very nicely

I checked back with the nursery where we had first seen the concrete benches, built in 1974, using polyethylene tubing instead of copper tubing. I was told that the polytubing has disintegrated to a point where the benches are totally inoperative. They looked so beautiful and had inspired us to build ours. I think we had good advice. It seems that the high initial cost of concrete benches containing copper tubing with circulating hot water would appear to provide us a propagation facility which is durable, safe, sanitary, low maintenance and economical to operate. While more costly to install initially than electric heating cables, they can be operated with an energy cost that is about ¼, using natural gas, than would be the case using electricity. As energy costs seem destined to continue to rise, we will consider use of solar panel boosters.

We are able to produce disease-free plants which come out at 80 to 85%. We've had these benches in operation now through three crops and have put through almost 375,000 trees, bringing the capital cost per cutting down to only about 2½¢ each in only three years. In considering that these benches will probably last 25 or 30 years, the investment appears to be warranted.

Thursday Afternoon, December 10, 1981

The Thursday afternoon session convened at 2:30 p.m., with Hugh Steavenson serving as Moderator.

COMMON SENSE IN PLANT PROPAGATION

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It has been 20 years since attending my first Plant Propagator's meeting in Washington, D.C., and, after attending some 16 IPPS meetings and over 100 nurserymen's short courses, nursery tours and trade shows, the same question always asked is "what's new?" Plant propagators and nurserymen are always looking for that new chemical which gives 100 percent rooting, or the new fertilizer or pesticide that solves all problems, or the machine that ends all labor. One hates to disap-