approaches 1-in. in length. This technique regularly yields a success rate greater than 90 percent and finished trees in the three- to four- (two- to five-) foot range. Recent tests with rose wax indicate that dipping the scions in wax prior to grafting may eliminate the need for the aluminum tenting.

HANDLING TISSUE CULTURE PRODUCED LINERS

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Abstract. Quality, competitive prices, and customer service are a must in the tissue culture industry. Quality includes health, branching, size, true-to-name, labeling, packing, and shipping. Stage II and III plants should be planted as soon as they are received and should follow a 4-week acclimatization procedure. Stage IV plants should be watered and placed in a shaded area as soon as they arrive. Transplant Stage IV plants as soon as possible.

The tissue culture industry started approximately 15 years ago. However, research in tissue culture dates back to the 1890s. Since then advances have been made in improving propagation, increasing production, developing new types of plants, and in producing disease-free plants.

There are a handful of laboratories above 15,000 square feet and many small operations around the country. At Plant Reproduction International, Inc. (PRI) we have an 18,700 ft.^{2} facility, which includes research and production laboratories. Our average capacity is 24 million plants per year. We have occupied our new facility for a year and our present inventory is 800,000 plants. Our goal is to reach 1.5 million plants in production by 1987.

Products and marketing. Tissue culture laboratories have had a non-competitive market for their products until two or three years ago, when two large tissue culture labs were started, one of them PRI. At present there is a market for tissue-cultured plants with better plant quality and competitive prices. Such competition is favorable for the growers and for the labs that know how to do it right. PRI visualizes that in the future the marketing competition will be much like the fashion industry, focusing on new, high quality, and competitive-priced products. It is for these reasons we emphasize research and development.

Our research department is currently working on introducing different types of plants into tissue culture, especially woody plants, and developing procedures for new introductions. PRI's research goals include short, mid- and long-term objectives in areas

such as clonal propagation, mutagenesis, *in vitro* fertilization, embryogenesis, anther culture, and callus culture.

At present we are working on over 35 different plant species totaling over 100 cultivars. Most of these plant species have never been propagated by tissue-culture techniques. Some of the species we plan to release soon are: compact cherry laurel, red bud, purple smoke tree, and water oak.

We are also producing woody plants that already have tissue-culture procedures worked out and published. Nandinas, rhododendrons, roses, blueberries, and daylilies are a few that are currently in production. Some of the other plants currently offered by tissue culture companies include alocasia, anthurium, apple rootstocks, azaleas, banana, Boston ferns, blueberries, daylilies, dieffenbachia, *Ficus* spp., gerberas, heliconia, kalmia, liriope, nandina, orchids, philodendron, rhododendrons, roses, schefflera, spathiphyllum, and syngonium.

Tissue culture stages. Tissue culture is a term that designates techniques used to grow explants in sterile cultures. There are four stages in plant tissue culture:

Stage I —Establishment
Stage II—Multiplication
Stage III—Rooting
Stage IV—Acclimatization

Most plants are sold as Stage IV—acclimatized liners. However, some are sold as Stage II—non-acclimatized, unrooted microcuttings, or Stage III—non-acclimatized, rooted microcuttings.

Products Stage II and II. After establishing the explants in a multiplication media, clusters of shoots are dissected in a transfer room under a sterile transfer hood. From one cluster it is possible to obtain from 5 to 20 shoots depending on the species. At this point larger shoots can be harvested as stage II unacclimatized, unrooted microcuttings, and the smaller are recultured for multiplication. Another possibility is to divide a cluster into smaller clusters for Stage III unacclimatized microcuttings or potting in the greenhouse. All tissue-culture plants should be graded (first selection) according to size, since tissue-culture shoots are not necessarily of the same size, e.g. dieffenbachia, syngonium, spathyphyllum, nandinas.

Plants for reculture go back to the growth room. Most growth rooms are maintained at 75 to 78°F with a 16-hour photoperiod.

It is good to see that the tissue-culture industry is improving the boxing and packing of their products. Stage II and III are being shipped in designed boxes; packing varies from newspapers to styrofoam boxes or styrofoam beads. Individual containers used are polybags, presspaper boxes, aluminium boxes, or plastic boxes.

The product should be uniform and of good size 1 to 1.5 inches. It should be either a microcutting or cluster, according to order, and should be clean of agar. Some labs ship with agar and do not select

their product. The main problems are uneven flats and plants with excessive callus that could lead to decay.

For stage III plants, shoots are rooted in the test tubes or as a regular cutting. In any case, before planting, plantlets should be rinsed with water to clean the agar or medium from the plantlet.

Several types of trays are used for planting. Most are styrofoam trays with 24 to 200 cells. These trays are inconvenient because of their size and cost. We have received tissue-cultured plants of several cultivars packed in one box, all mixed up. The plugs were out of the cells and many times there were no labels or the labels were out of place and mixed up.

Flexible trays are a problem for shipment. The most widely used are those with a rigid edge, which come in a variety of sizes including 72-cell, 96-cell, 200-cell, and 288-cell trays. Some trays have a round cell and others have square cells.

We have tried several commercial mixes and we were able to get only one that has a peat:perlite mix for plugs. This mix is used for foliage plants but it retains too much water for woody plants. Woody plants require a mix with better drainage. We are testing a bark:perlite and a bark:peat:perlite mix. There are also sponge and rockwool products.

Acclimatization. When microcuttings are received they should be graded for size (second selection) and planted immediately in a shaded area and placed under high humidity conditions and shade. The reason for this is that the plants are grown in closed containers and are susceptible to wilting. Acclimatization follows a series of changes to lower humidity and increased light for hardening off. This process takes approximately four weeks.

There are several ways to accomplish acclimatization. Humidity tents on individual trays, plastic covers on individual trays, or tents over beds are all satisfactory. The source of water could be a regular mist system or a fog system. The end product should be completely hardened for regular growing conditions.

Product—Stage 4. Stage IV trays should be inspected for empty cells, size of shoots, health and color before shipment in order to guarantee higher quality. This is the third selection that tissue culture plants undergo. A case generally consists of 144 plants and should include a growing recommendations sheet. All trays should be correctly labeled.

In a box there is a division and 2 holders to secure the trays in place and to avoid crushing of the plants. When plants are received *they should be potted as soon as possible under the recommended* conditions. Nandinas should be planted directly in the field for field container production and the same procedure should be followed for any other outdoor plant. Foliage and greenhouse plants should be planted under conditions for greenhouse crops.

Advantages of tissue culture liners. Growers should enjoy

advantages of tissue culture, such as:

1. Uniformity
2. Programming of crops
3. In some species, better plant branching resulting in better products
4. Disease-free plants
5. Availability

Our goal should be for quality, efficiency, and customer satisfaction. Tissue culture is a useful technique for propagation in the horticulture industry and should not be blamed for the subsequent mishandling by producers and growers.

QUESTION BOX

Moderated by Carl Whitcomb and Bryson James

JOE POWELL: David, do you use lime in your propagation mix?

DAVID SABALKA: No. As Carl Whitcomb has pointed out, we can pick up all we need from other sources, such as water.

RICHARD ODOM: Have you tried rooting using Micromax, but no Osmocote?

CARL WHITCOMB: Yes. However, I do not recommend using Micromax unless you also use at least 4 lb. Osmocote 18-6-12/yd.^{3} Start out at the low rate. Also, be careful about mixing large batches as Osmocote may begin to release. We have found supression of rooting when most other fertilizers or formulations of Osmocote were tried and therefore use only 18-6-12 Osmocote.

RICHARD ODOM: When do you begin to see trouble from Osmocote if the rate or application method has been wrong?

DAVID SABALKA: It depends on the watering and soil temperature. We don't ordinarily have problems in the winter. Most of the time toxicity problems will show up within the first four to six weeks.

JIM BERRY: What is a dangerous salts level?

BRYSON JAMES: If the mix is 2:1 bark:perlite, no fertilizer is needed at first; 18-6-12 Osmocote doesn't release for about three to four weeks, which is about right. A salts level higher than one micromho is too high in a 2:1 mix. There are many methods of testing and expressing soluble salts concentrations. It is important to use one method consistently and monitor changes. Once you determine the level at which your plants do best, that level can be used as a guide for making needed adjustments in fertilizer pro-