WHAT'S NEW IN PLANT PROPAGATION?

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In the revision of the textbook by Hartmann and Kester, *Plant Propagation: Principles and Practices,* for the 5th edition, we have been searching the horticulture literature for new significant developments in plant propagation that justify being covered in a plant propagation book. We have considered a number of important emerging situations that will be discussed in this paper.

In the first place, we have added a new co-author to our book, Dr. Fred T. Davies, Jr. of Texas A & M University. Dr. Davies was president of the IPPS Southern Region in 1986.

PROPAGATION FACILITIES AND EQUIPMENT

Greenhouse coverings. In the past the principal coverings have been glass, polyethylene, and fiberglass. Two promising new materials are acrylic (Plexiglas, Lucite, Exolite) and polycarbonate (Polygal, Lexan, Cyroflex, Dynaglas). They are available in rigid, double-wall construction that gives good insulating properties. Some have inside coating that prevents condensation, droplet formation, and dripping. These materials are unlikely to replace the great popularity of the less expensive polyethylene, single and double, coverings, but they do give another alternative, particularly as a glass substitute.

Computerized greenhouse environmental controls. Computer equipment is available now to control all aspects of the greenhouse environment—heating, cooling, ventilation, humidity, shade and energy curtains, irrigation, fertilization, lighting, and CO_2 enrichment. The continuous recording of the information permits reviewing the complete operation and changing the patterns if necessary.

Nurseries in The Netherlands and Belgium are the leaders in computerized greenhouse controls but there are a number of such installations in the U.S. There are several companies that offer these installations, for example, Priva, Ontario, Canada; Oglevees, Connellsville, Pennsylvania, and Wadsworth Control Systems, Arvada, Colorado. Computer greenhouse controls are quite costly for the initial installation.

Premixed propagation and growing mixes. These are soil-free mixes prepared by many companies in bagged and bulk forms and are available in many combinations of materials. Of a survey[1] of 120 commercial mixes, almost all contained peat moss, most con-

[1] Premixed media, *Greenhouse Manager,* September, 1988, pp. 120–131.

tained vermiculite, and a few had perlite; almost all had, as additives, limestone and a wetting agent; many had a starter fertilizer and trace elements. Very few had bark, sawdust, or rockwool; two contained some soil; a few had gypsum, bentonite clay, or a pH buffer.

Some companies will deliver mixes to large nurseries already loaded into cell packs, seed trays, or pots.

Fog installations. These are being used more and more despite their high cost. Fog has the advantage of producing very fine water droplets, from 20 to 30 microns, that stay suspended in the air, increasing the RH to nearly 100%. It does not leach nutrients from the plant leaves or waterlog the media. Mist, on the other hand, has water particles 50 to 100 microns in size which settle out rapidly. Three types of fog generators are currently available: (1) The Agritech and Humidifan systems, that forces air through water being ejected from a spinning nozzle with the atomized water being forced into an air stream by a fan attached to the rear of the unit. (2) The Mee system, where water is forced under high pressure, 500 to 1000 psi through mist nozzles with very fine orfices. The water then hits an impact pin which atomizes the droplets to less than 20 microns in size, producing a dense fog. (3) Sonicor Ultrasonic humidifiers (made in England) use compressed air and water. Water is disrupted by passage through a field of high frequency sound waves, generated by the compressed air, to create a dense fog.

With fog, good controllers are necessary; they should operate to maintain a fixed RH. Time clocks do not work satisfactorily.

Good sources of information on greenhouse facilities and materials are the trade magazines, *Grower Talks*, published by Geo. Ball & Co., West Chicago, Illinois, and the *Greenhouse Manager*, published by Branch-Smith Publishing, Fort Worth, Texas.

SEED PROPAGATION

Seed physiologists are continually conducting research on the mechanisms of seed development, dormancy, and germination but much of this work has no direct application for the practical plant propagator. Nevertheless, seed propagation is a fertile field for studying dormancy (6), hormone physiology, enzyme physiology, genetic and environmental relationships.

Somatic or "artificial" seeds Somatic embryogenesis is a promising new development—a vegetative form of propagation, using cell culture methods (16). Somatic (vegetative) seeds are produced from embryos grown from callus, cells or protoplasts; the embryos are then encased in an artificial protective seed coat. Thousands of encapsulated somatic embryos can be clonally produced from a single plant. Somatic or "synthetic" seeds have been produced from grains, vegetables, oil and date palms, coffee, and conifers. This, then, is a potential for clonally producing new plants of difficult-to-root species by avoiding convential propagation methods, but using clonally produced "artificial" seeds.

Bedding plants and plug production There has been tremendous growth of the bedding plant industry and the ever-increasing use of mechanized plug production for seed propagation of annual and perennial herbaceous ornamentals and vegetable crops. This is a great story in itself (11, 14). Bedding plant production in the U.S. in 1976 was 64 million dollars, in 1986 it was 232 million dollars. There are over 1.5 billion plugs a year produced in the U.S.—and climbing (3).

Seedling plants for plug growing are best started in fog (40 to 60 micron water particles) with root-zone heating. One should start feeding plug sheets about 2 days after sowing. Supplementary light should be used, especially in winter and in areas furtherest from the equator. High pressure sodium vapor lamps are good to use—250 to 1000 ft. candles. Best to use movable boom irrigation. Almost everything about plug production is or can be mechanized—seeding, growing, and transplanting.

CUTTING PROPAGATION

To date, adventitious root formation remains one of the least understood of plant functions. Despite years of active research the primary chemical stimulus for adventitious root formation remains unknown. And no chemical has come forward in the past 5 years to replace IBA or NAA as a stimulator for adventitious root initiation, although the K salts of both these chemicals are being used more widely, due to their water solubility.

Etiolation Etiolation of the stem tissue from which adventitious roots are to form has long been known to stimulate root initiation (2). The recent renewed interest from the studies of Maynard and Bassuk (1, 7, 8) at Cornell and the earlier work by Howard (5) at East Malling have elucidated some of the mechanisms involved. They have also shown how practical use can be made of etiolation to improve rooting of difficult subjects. Maynard and Bassuk's use of Velco strips—dipped in IBA/ talc powder, then used for banding around the etiolated stem bases is a most imaginative treatment for injecting IBA into stem tissue during the etiolation process. Etiolation seems to make plant tissue much more sensitive to auxin.

Stock plant irradiance This is proving to be much more significant than previously believed. In a study (4) with 24 species tested, *increasing* light intensity *decreased* rooting with 14 species, *increased* rooting with only 6 species, whereas little or no effect was noted with 5 species. A generalization is difficult, but is seems that with most species using moderate light conditions for the stock plants is likely to promote rooting, as compared to high light conditions.

Direct sticking of cuttings This is best used for easily-rooted, quick-growing species. It is best to take cuttings in mid-summer, using new growth with cuttings set 3 to 4-liter pot. A peat-based rooting medium having a slow-release fertilizer added works well (12). They can be rooted in a poly-covered quonset house under mist or fog, with saleable plants ready about 12 months later. A disadvantage of direct-sticking is the increased space requirement.

Bacterial root induction Root induction by inoculation with *Agrobacterium rhizogenes*, a naturally-occuring bacterium, has induced roots to form on stem tissue of difficult-to-root species (14). This is also known to incite hairy-root disease, which is characterized by adventitious root production at the point of infection. This practice has the potential to induce roots in difficult species (9).

GRAFTING AND BUDDING

Chip-budding One of the most significant developments in this category is the increasing use of chip-budding in the propagation of fruit and ornamental trees. Many large nurseries are finding chip-budding to be completely satisfactory. It has the advantage of not requiring the bark to be slipping, thus extending the budding season. Studies by Howard and co-workers (13) in England have found a better healing and vascular connection with chip budding than with T-budding. Chip-budding seems to be most successful in areas with cool growing seasons, while T-budding is quite satisfactory in areas with warm to hot growing seasons.

Simultaneous grafting and rooting There seems to be more interest in this type of propagation in recent years, although it has long been used in the propagation of citrus. An interesting recent example is in the propagation of roses in The Netherlands where it is given the name "stenting" ("stekkenn", to strike a cutting, plus "enten", to graft). A leafless rose rootstock cutting of an easily rooted material is prepared onto which the leafy scion cultivar is grafted—by some type of machine grafting—then the combination is placed under mist so that graft heals while the rootstock cutting roots (17).

Predicting incompatible graft combinations In the past, trial and error was the only way to know for sure whether or not a graft combination was going to be successful—and the results might not be known for years. Santamour (10) at the U.S. National Arboretum in Washington, D.C. has devised a unique test that predicts the success or failure of a proposed graft combination. He has been testing his method on a wide range of woody plants. An electrophoresis test is used, examining cambial peroxidase banding patterns of the proposed scion and stock. If the patterns match, then the combination may be said to be compatible; if they do not then incompatibility may be predicted. A simple electrophoretic diagnostic system is being developed to allow propagators to perform the procedures themselves.

TISSUE CULTURE

A great many new species and cultivars are continually being described in the horticultural literature that have been propagated by micropropagation techniques. The techniques of tissue culture are also being continually refined and improved to increase the success rate. Formerly success was obtained only with herbaceous material. Now all types of woody perennials are also giving good success. Testing is underway to determine if plants propagated by tissue culture perform as well as those propagated by conventional methods, which has generally been the case.

Micropropagation by tissue culture is in the process of finding itself—where and with what plants it is feasible to use economically. In some instances the market has been flooded with certain tissue-cultured plants and some large outfits have been pulling back from such extensive propagation. The problem of avoiding variability in the product is something that must also be faced in micropropagation.

RECENT IMPORTANT PLANT PROPAGATION BOOKS

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