FERN PROPAGATION

Except for a few cultivars, our ferns are grown from spores. New wood or plastic flats, are filled with spaghnum moss then steam pressurized at 180°F for two hours. The spaohnum flats are then placed on Physan-treated benches and planted immediately with the spores. They are then covered with plastic lids to keep moisture in and minimize the settling of air-born fungal and bacterial spores on the surface. All potting soils in fern propagation are fumigated with methyl bromide, and only new or fumigated pots are used. Ferns grown from plantlets, as *Asplenium bulbiferum*, must have the plantlets washed in 5 ppm chlorine and 200 ppm Physan before planting.

SEED PROPAGATION

Most of our seeds are bought from other companies but any seed that we collect is cleaned and inspected for disease. All seeds, whether bought in or collected, are surface-treated before planting with Thylate, a fungicide. The seed planting medium is put into wood flats and steam pasteurized at 145°F for two hours. After the seeds have been planted, a thin layer of silica sand is put over the surface of the flat. The sand, being inorganic and quick drying when the flats are watered, minimizes surface fungal growth.

CONCLUSIONS

Monrovia is continuously researching new and better ways to control disease throughout the nursery. Insect control is important also, as insects may carry pathogens from plant to plant. Future research projects for the propagation department include a chlorinated mist system. Disease prone plants may have to be kept continuously immersed in Physan solutions from the time they are collected in the field to the flatting of the prepared cutting in the cutting shed.

NEW VISTAS IN PLANT PROPAGATION

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The plant propagator and the nursery industry are in the most fortunate position of being able to benefit from the result of research in many disciplines and many applied fields.

Plant breeders are continually developing new plant material, some of which eventually becomes important in the nursery trade. Plant introduction programs and arboreta often bring in valuable new germplasm to be used directly, or as a gene source for introducing, by plant breeding, new characteristics into present plant material. The biochemists, plant physiologists, and botanists develop new growth regulators, herbicides, fertilizers, and such new techniques as tissue culture. They also study plant structure, adaptation to the environment, and plant functions, to give us a better understanding of plant behavior. Entomologists and plant pathologists develop new chemicals and new techniques for controlling insects and diseases, while the engineers design new propagation facilities and equipment used for such things as greenhouse heating and cooling, container growing, and aerated steam soil pasturization.

The big challenge to the plant propagator is to become aware of new developments in all these areas and to make use of them. It is a major task just to keep up with the literature and new developments in all these fields. Much ongoing research, which eventually becomes of great value in plant propagation, is not directed toward solving nursery problems, but is a spin-off from other projects. So the plant propagator, in order to make significant steps forward in reproducing plant material must continually be on the lookout for advancements in all these related fields and tie into those new developments which can be of value to him.

Looking back at the history of plant propagation there is a series of major milestones which have created great leaps forward.

Early prehistoric man had undoubtedly learned to propagate woody food producing plants vegetatively by hardwood cuttings and by layering so as to perpetuate the best selections available to him. Some of the most ancient fruit crops are among those easiest to propagate by hardwood cuttings — grapes, figs, olives, pomegranates, and mulberries. Cultivar selections of superior forms were, no doubt, being made and propagated by early man. Possibly some early hunter, chasing an animal, stuck his sharpened spear into the ground and later found it growing. Thus propagation by hardwood cuttings was born.

Grafting was an art well-know to early civilizations and is shown in their pictures and writings. It is interesting to speculate how the first grafting operation may have occurred. Perhaps the hunter, chasing an animal, missed and stuck his sharpened spear into a tree. If the spear was of living wood, and stuck just at the right angle into the cambium area of the tree and, if the two were compatible, then perhaps his spear would have started to grow — thus the art of grafting was born.

Later, through the centuries, the invention of glass permitted lighted, high humidity enclosures which enabled propagation by leafy cuttings — which was certainly a big step forward. In the 1930's plant propagation received a big boost through the study of auxin physiology and the finding that such materials as the synthetic auxins — indolebutyric and naphthaleneacetic acid — had the ability to stimulate adventitious roots on stem tissue.

Mist propagation, starting in the 1940's and 1950's, the widespread use of polyethylene sheeting in the 1960's, and container growing gradually becoming more widespread during the 1950's, 60's, and 70's, have been major events in plant propagation history.

The most recent major development in plant propagation, of course, and one we are standing in the middle of right now, is the use of aseptic tissue culture techniques for large scale reproduction of plants. Many nurseries right now have established tissue culture laboratories and are propagating commercially plant material such as chrysanthemums, orchids, Boston ferns, *Dracaena*, *Cordyline*, and *Diffenbachia*. Tremendous quantities can be produced in a short time; for example, techniques have been refined to the point where 100,000 lily plants can be produced in 6 months starting with one medium sized bulb (3). Tissue culture in Araliaceae can result in 5 million transplantable plants for each 3 to 5 mm explant within one year (10).

If we turn and look toward the future in plant propagation, what do we see? Immediately, we see explosive developments in the field of plant tissue culture. Looking through recent issues of the IPPS Proceedings, one is impressed by the increasing numbers of articles dealing with tissue culture methodology and the increasing numbers of plant species that are being successfully reproduced by these techniques. Similar articles are also appearing in most other plant science journals.

Articles and books are being written dealing with tissue culture techniques for the plant propagator. Murashige's review (11) in the Annual Review of Plant Physiology entitled, "Plant Propagation through Tissue Cultures", stated the progress made in this area as of 1974.

In 1976, deFossard published an excellent 400 page book entitled, "Tissue Culture for Plant Propagators" (5). It can be ordered from: The Department of Continuing Education, University of New England, Armidale, N.S.W., Australia, for $10.00 Australian, plus postage.

The book, "Plant Tissue Culture Methods" by O.L. Gamborg and L.R. Wetter, contains easy-to-read instructions on the techniques of tissue culture. It is available from the National Research Council, Ottawa, Ontario, Canada K1A OR6, for $6.00.

Organizations directed toward the promotion of tissue culture techniques include the International Association for Plant Tissue Culture, which was organized in 1971. Application forms for membership are available from the National Correspondent for the U.S.A.[1] This group is holding its Fourth International Congress of Plant Tissue and Cell Culture at Calgary, Canada, August 20 to 25, 1978. This meeting is open to all interested persons. The IAPTC also publishes a quarterly Newsletter containing articles and news on developments in plant tissue culture.

The Tissue Culture Association[2] is concerned with aseptic cell, tissue, and organ culture of both animals and plants. It owns and operates an educational and research facility — The W. Alton Jones Cell Science Center in Lake Placid, New York. Membership in this organization is open to scientists and technicians active in the field of tissue culture, who have the B.S. degree or its equivalent. The Plant Division of the Tissue Culture Association gives short courses at Lake Placid, entitled "Tissue Culture Techniques for Plant Propagators". The next scheduled courses are September 25 to 30, 1978. The TCA also publishes a monthly journal, *In Vitro*, and a quarterly *TCA Report*. An annual meeting is held by the TCA in which papers dealing with both animal and plant tissue culture are presented.

An International Congress on Tissue Culture sponsored by the International Society for Horticultural Science was held in Belgium in September, 1977, and during this same month at Ohio State University a symposium entitled, "Plant Cell and Tissues Culture: Principles and Applications", was held. The papers presented at the ISHS Belgium meeting will be available in an issue of *Acta Horticulturae*.

In the past, propagation by tissue culture techniques seems to have been limited to herbaceous plants, but articles are now appearing describing propagation of such woody plant species as *Malus* (1,6), *Tsuga* (4), *Ficus* (9), and *Tupidanthus* (10).

Obviously, nurseries wanting to stay on the front line of new propagation techniques must watch developments in the field of tissue culture and fit in where they can. Aseptic laboratories, equipment and trained technicians to do this type of work are required.

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[2] TCA Business Office, 12111 Parklawn Drive, Rockville, MD 20852.

Where are there other opportunities for productive developments in plant propagation? The juvenility influence on production of adventitious roots in cuttings has been known for many centuries, yet the mechanism involved is little understood. If we knew what rooting promoter(s) occur in cuttings taken from young seedling plants (but not found in more mature plants), or what rooting inhibitor is produced as the plant ages (12) — or some combination of the two — this could have great implications in propagation by cuttings of difficult-to-root clones and would be a real step forward.

Considerable interest has been shown in the past few years in increasing research activities on juvenility in woody perennials, not only in understanding the mechanisms involved, but in learning better how to make use of this phenomenon in rooting cuttings and in bringing seedlings through the juvenility period faster to aid plant breeders in evaluating their seedling selections.

In 1975 two symposia on juvenility in woody perennials were held, the North American symposium at College Park, Maryland, and the European symposium in West Berlin, Germany. The papers presented in these two symposia were published by the International Society for Horticultural Science in the *Acta Horticulturae* series (13).

At the University of California, Davis, a new research project has been established jointly by the Departments of Pomology and Environmental Horticulture to study the mechanisms involved in juvenility — from the standpoint of regeneration and of regulation.

The practice of etiolating stem tissue has long been known to cause the production of adventitious roots on stems of difficult-to-root plants, yet there is little information on the mechanisms involved. Stems held in complete darkness are much more likely to form roots than similar tissue exposed to light. Intensive research into this field could uncover some valuable leads into the biochemistry involved in the initiation of root primordia in stem tissue.

Studies (7) using Pinto bean indicate that in this plant there is photoinactivation of root promoting factor(s) by exposure to light. Treatment of bean stem tissue with a phenolic compound, 2,4-dinitrophenol caused production of adventitious roots, particularly if indoleacetic acid was also applied, provided the tissue was subsequently kept in darkness by covering with opaque tubing. When covered with transparent tubing, no roots formed. Mixing 2,4-dinitrophenol with a solution of chlorophyll and ascorbate (both occurring naturally in stem tissue) in a test tube and exposing to light caused a conversion of the 2,4-

dinitrophenol to 2-amino, 4-nitrophenol, which had no root inducing properties. If kept in darkness, this did not occur. Further studies of this nature with other kinds of plants may be of considerable value in determining if the benefits of etiolation are due the production of light sensitive rooting factors. Possible characterization of the substances involved may lead to useful materials which could substitute for the etiolation effects.

What is there in the future in the area of grafting and budding that could develop into a major breakthrough and permit wider usage of grafting technique for those kinds of plants known to be difficult to propagate by grafting or budding and, perhaps, almost impossible to propagate by other methods?

One of the basic reasons for grafting failure in these difficult plants is the lack of the all-important callus production at the graft union. Some kinds of easily grafted plants, as grapes, apples, and pears, will produce callus profusely at cut surfaces while other difficult-to-graft plants, as the oaks, are notoriously poor callus producers. Treatment of cut graft surfaces, ready to bring together to make the union, with chemical substances which would promote callus production could lead to greatly increased grafting success. Reports in the literature from aseptic tissue culture studies, aimed at causing new plant regeneration, are replete with results in which certain treatments caused only massive amounts of callus to be produced. Certain combinations of kinetin and auxin will do this. Such treatments could very well be of great value in grafting where stimulation of heavy callus production is needed. There is room for considerable research into this area and it could lead to results of great benefit in grafting and budding procedures.

What is in the future in rootstock development? With the increasing interest in smaller, compact fruit trees and woody ornamentals, often planted in high density arrangements, there is a great need for new size controlling rootstocks similar to those now available for apples, as pioneered in England for many years by the East Malling Research Station.

The activities of the International Dwarf Fruit Tree Association[3] in setting up their Rootstock Research Foundation, if successful, may lead to the development of equally useful size controlling rootstocks for other species.

The interesting work in the development of genetic dwarf plants may bring similar results by a different route. For example, in a new fruit breeding project at the University of California, Davis, a genetic dwarf peach selection, yielding 21 tons per

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[3] Executive Secretary, R.F. Carlson, Dept. of Horticulture, Michigan State University.

acre in the second year after planting the nursery trees, has been developed. Such clones are propagated by budding 18 inches high on standard peach rootstocks, such as 'Nemaguard', with various planting densities of 500 to 3,000 trees per acre being used. Dwarfness is due to very short internode length, the trees having as many leaves as full sized trees. In such high density plantings of small trees, pest and disease control, and mechanical harvesting, would be much easier than for full sized trees. In this project, fruit quality has yet to be bred into the dwarfed high yielding selections.

What may be ahead in plant growth regulators that may be useful in plant propagation? Growth regulator research received a considerable stimulation with the formation of the Plant Growth Regulator Working Group,[4] organized in 1973. Annual meetings are held and membership is open to anyone interested in research with plant growth regulators. Abstracts of the meetings are available, as is the Quarterly PGR Bulletin. A new 94 page Plant Growth Regulator Handbook (2) was published in 1977 giving information on recently released synthetic plant growth regulators.

No growth regulators useful in stimulating production of adventitious roots on cuttings that are better than the long standard indolebutyric acid and naphthaleneacetic acid are appearing. Information being developed from tissue culture studies on the effects of cytokinins may lead to more widespread use of this material in propagation by leaf and root cuttings since it is active in promoting cell division and bud and shoot development. The synthetic cytokinins, N-6 benzyladenine, 6-furfurylaminopurine, and PBA (6-benzylamino) -9- (2-tetrahydropyranyl) -9- H-purine (to be marketed by Shell Agricultural Chemical Company under the trade name "Accel") are low enough in cost to be economically useful in propagation practices.

Ethylene gas is known to stimulate roots on stem tissue and perhaps future research will show positive results in the application of ethylene releasing compounds, as ethephon, for rooting cuttings. Evidence to date, however, is somewhat conflicting.

These are some of the areas where the future holds promise of new exciting developments that may materialize into useful benefits for the plant propagator. There are others, of course. For example, there are reports (8) that adding mycorrhizae fungi, or extracts of the fungi, to the rooting medium have enhanced rooting of bearberry and huckleberry cuttings, possibly due to synergism with auxins.

[4] Dr. E.F. Sullivan, Business Manager, The Great Western Sugar Company, Agricultural Research Center, Sugar Mill Road; Longmont, Colorado 80501.

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SUBTROPICAL FRUIT TREE PRODUCTION: AVOCADO AS A CASE STUDY

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Abstract. A general description of techniques in a modern commercial avocado tree nursery and a summary of special precautions for the prevention of infections by *Phytophthora* organisms, sunblotch virus, and *Rhizoctonia* are given. Also, a description of special procedures for seed storage and a recently patented method for producing grafted avocados on clonal rootstocks in described.

INTRODUCTION

I have chosen avocados to discuss because, frankly, the avocado (*Persea americana*), is one of the few plants I know any-