PRESIDENT STEVE FAZIO: This morning I would like to welcome all of you to the twenty-first annual meeting of the International Plant Propagators' Society, Western Region. I would like to do something a little unusual that we haven't done before. We have a large group of new member New members, if this is your first meeting, you are in for a treat. You are going to be exposed to new research in plant propagation and you are going to see some new techniques and innovations in the nurseries that we are going to visit on our tours. Our motto, if you are not familiar with it, is in Latin on the front of your program; it states; "To Seek and To Share." This is what we do. We have no secrets. All of these people that you will visit on the tours and the speakers on the program will be glad to tell you all about their propagation procedures, and so on. So, to you we dedicate this program, this meeting this year, and we hope that you will find it very, very interesting and worthwhile.

THE PHILOSOPHY OF THE I.P.P.S.

RALPH SHUGERT
John Zelenka Evergreen Nursery, Inc.
Grand Haven, Michigan 49417

The thoughts I shall share with you will be centered from the title — The Philosophy of the I.P.P.S. Mr. Webster's dictionary, in defining the word "philosophy," will guide our discourse. He suggests three concepts for the word philosophy and we shall share together the relationship of the dictionary definition and our beloved Society.

Philosophy — "The study of the causes and relations of things and ideas." This first dictionary concept will allow us to reflect upon the beginning of the International Plant Propagators Society and some thoughts shared during the founding of the Western Region As we look back in history, we learn that our Society is traceable to the existence of a previous and somewhat similar group. An organization known as, "The National Association of Propagating Nurserymen," was formed in 1919 and survived until 1931, at which time it succumbed due to the severe economy of the period. At the Eighth Annual Meeting in 1927, the name was changed to the "American Plant Propagators Association." The constitution allowed membership eligibility for nursery firms "engaged in the propagation of nursery stock for lining out in nursery rows," but disallowed membership to the academician, florists, and only to those propagating nursery stock for United States distribution. As Al Fordham noted, "One won-

ders if this stipulation could lead to expulsion of a member doing foreign business!" The 12th and final meeting was held in Detroit in 1931, and the Society did not convene again.

The review of our predecessor society allows us to study the cause of ideas, because it was exactly this philosophy which created the association known today as, "The International Plant Propagators' Society." In November of 1951, in Cleveland, Ohio, an enthusiastic assembly of about 100 people enjoyed a two-day program to discuss plant propagation. At this meeting a committee was appointed to draft a constitution and the meeting produced a printed Proceeding of 50 pages. For an example of growth and development, the Proceedings of the 1978 twenty-eighth annual meeting consisted of 661 pages!

The history of your Western Region is equally fascinating with initial action going back to the summer of 1958, followed by a meeting in June of 1959 at Davis, California, which was attended by 22 interested and devoted individuals. At the first formal meeting of the Western Region, Webster's second definition of Philosophy is exemplified by the words, "The serene wisdom that comes from calm contemplation of life and the universe." It was in 1960, at the Western Region First Annual Meeting that Dick Fillmore suggested that Society membership could be a "lessening of professional loneliness." Also at this meeting, the keynote address, presented by Jim Wells, truly pointed out that the plant propagator is indeed the basis of our industry.

In reflecting on the dictionary words of "calm contemplation", those words have meaning sitting in an airplane returning home from a conference. However, all the meetings I have attended afford very little "calm contemplation" in the meeting rooms. How vividly I recall Harvey Templeton's first discussion relative to constant mist. I recall the frenzy of excitement that paper generated and the few comments that it would never work — "You will drown the cuttings!" The impact of that paper, and the ensuing multitudinous words which followed, truly revolutionized the propagation practices throughout the world. For the benefit of the guests in the assembly, I urge you to attend the Liars Forum this eveing, since I assure you that Jolly Batchellor will not create an atmosphere of "calm contemplation!"

During our philosophic "study of ideas" we are amazed with the advances of tisssue culture as a plant propagation techique and you shall be hearing words of wisdom on this practice this morning. All of us can be justifiedly proud of the fact that much technological advance in plant propagation was promulgated by the I.P.P.S. It is a unique body truly adhering to the principles of the motto — "To seek and to share." The Society is strong because of its members dedication and the union of the person

concerned with the scientific investigation as well as those involved in the more practical aspects of commercial plant propagation. The constitution of the preceding society in the 1920's has been radically altered for the best. We now have the exchange of thoughts between the academic and practicing nurserymen, and the restriction of the distribution is no longer valid. Quite the contrary; we have a strong, devoted, membership from Canada in both the Eastern and Western regions, and with recent Region formations in Great Britain, Australia and New Zealand we are today truly "international" and I would predict that other areas around the world shall someday attain regional status.

The final definition of Philosphy tells us it is, "A system of thought or ethics." The final word in that quotation is ambiguous, to say the least. In reviewing the Proceedings, a member might challenge the ethics of budding or grafting *Syringa* cultivars on *Syringa vulgaris* seedlings. Be that as it may, but the ethics of a sound propagation program are constant and feasible. The vast amount of knowledge which can be gleaned from our Proceedings — and from our meeting this week — affords all of us the true potential of producing a better plant. An opportunity to be a wiser and better individual due to our accomplishments.

It was amusing to read the words of Alfred Hottes as he was introduced at the 1926 meeting as the author of a book on propagation. Part of his response to the introduction includes these words: "Books on propagation are not made the way poems are — out of pure fabrication or a trip to the cave It is a person who investigates after long hours of work and study who can properly produce a book on plant propagation." I feel confident that both Hudson Hartmann and Dale Kester would agree, and neither of them took any "trips to the cave."

My friends, the Philosophy of the I.P.P.S. is communicating, seeking — sharing — the many facets found in the art of plant propagation Henry David Thoreau said, ". . . if life proved mean, why then to get the whole and genuine meanness of it; or if it were sublime, to know it by experience." Our Society has created a treasure chest of vast amounts of plant propagation information derived from the experience of the plant propagator. The legacy of our art is indeed in good hands with the members of The International Plant Propagators' Society. In no other profession is the definition of the word Philosophy so apropos. We are all so very, very fortunate to be engaged in the stimulating science of propagating plants. During this session, I urge all of you, once again, to seek and share your talents.

NURSERY PRODUCTION IN ORANGE AND LOS ANGELES COUNTIES, CALIFORNIA

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Nursery production has grown to a high level in Orange and Los Angeles counties, California, despite the rapid urbanization. In contrast, many other types of agricultural production have been greatly reduced.

The dollar ornamental plant production figures for each county went over the 100 million dollar mark in 1979. Several major types of ornamental production are included in the 100 million figures, however, the major part of the production is outdoor container-grown woody ornamentals. This production in the two counties represents a major share of the container-grown woody ornamentals in California.

Both local use and out-of-state sales are important in the marketing of these products. The continued strong urban development in California and superior climate for outdoor production in comparison with many other areas in the United States has been a factor in the expansion of the industry. The ready availability of transportation, an adequate supply of labor and materials, and a highly favorable growing climate have all contributed to expansion of the industry.

Nursery size can vary from the small grower using one or two acres of land to those who grow on 100 or more acres. Nurseries are scattered throughout the basin. Many are located under the power company transmission lines, placing them at times in the middle of urban development. The larger sized nurseries are more often in the more outlying areas with several of them in the eastern part of Orange County.

With the long dry season, sprinkler irrigation is the rule for most of gallon-can container production areas with drip or tube irrigation increasingly being used for the larger-sized containers. The soil mix is typically light weight due to the advantage of handling and the reduction in weight for shipping. Shipping weight has become increasingly important with higher energy costs and their effect on transportation rates.

With the factors mentioned above, plus others, the Orange-Los Angeles County area has developed into one of the major areas for production of container grown plants. The expansion of nursery produciton has helped keep agriculture viable in a major urban area.

TISSUE CULTURE PROPAGATION OF NORWAY AND SUGAR MAPLE

TSAI YING CHENG

Oregon Graduate Center
Beaverton, Oregon

(Dr Cheng was unable to prepare a manuscript for her talk)

PROFITABLE TISSUE CULTURE

MARTIN J. CREHAN

Plant Tissue Culture Lab.
1232 South Bonnie Cove
Glendora, California 91740

My wife, Elyse, and I considered starting a plant tissue culture lab when my previous employer, Sherman Orchid Gardens in Glendora closed its business of growing cymbidium orchids for the wholesale cut-flower trade. During my 25 years there we had followed the work of Dr. Morel of France on the tissue culture of cymbidiums. Within ten years of the first meristeming of cymbidiums, Mr. Sherman sold out for, with the advent of fan and pad cooling of greenhouses, and the availability of good hybrids the market became oversupplied.

My whole career has been in the horticultural field, including two years at an agricultural school on Long Island, New York, student gardener training at the New York Botanical Garden, plus some work at Kew Gardens in England; therefore tissue culture seemed like the next logical step

Therefore, after a year's study of literature at the California Polytechnic University, Pomona, California, we took a three-day intensive tissue culture course at the University of California, Riverside, under Dr. Murashige. Following the details for constructing a small lab given during the course we proceeded to construct our lab. We converted our garage, measuring 20′ × 25′, by running one-half as an insulated room for the hoods and for shelves for the bottles; the other half was considered our work area. Later we constructed a 13′ × 30′ greenhouse and utilized a three tier bench arrangment which made its capacity — 400 flat size. We installed a desert cooler, gas heater, humidity set-up, circulating fan, and used Saran cloth on the outside for shade.

For equipment — our two hoods were procured from Ray Products in El Monte, California and are the type used in assembling electronics, costing around $350 each. Our balance scale

was secured from a used-scale dealer. Our son, Martin, and Dave, a neighbor, built our wheel patterned after the one at University of California, Riverside, which incidentally has now been copied for the eighth time. The wheel has five revolving drums and holds approximately 400 test tubes which revolve once every 57 seconds.

Our shelves are 2′ × 8′ and 18″ distance from the fluorescent tubes; and are of pressed wood. Incidentally do not purchase second-hand fluorescent fixtures.

The walls of the culture room were insulated and covered with masonite, which was then painted white. On the floor of the culture room a grade of linoleum was used which is now disintergating and will now have to be replaced. Most of our original lab supplies were purchased from Van-Waters & Roger; now we deal with Scientific Products. However for the second stage bottles in the fern production we use discarded bottles which were used at a local hospital for intravenous injections. In order to cool the culture room, a small in-the-wall cooler was used; due to the insulation no auxilliary heat is needed.

At first we used our electric stove in the kitchen to prepare and sterilize the media; later a used two gas burner was installed in the work room and a roof fan installed to remove the fumes.

Our employees are usually part-time students from Cal-Poly, or the local high school who average 20 hours per week and receive $5.50 per hour.

I deliver the plants to the customers and they, in turn, save the used flats and inserts, which upon return are soaked in a chlorine solution for 24 hours, reassembled and rinsed with clear water and left in the sun for 24 hours.

Potting soil. We started with a peat-lite mix recommended by U. C. R. Extension, which did not prove satisfactory. The Soil and Plant Laboratory, Orange, California then recommended a soil mixture and feeding program. This worked satisfactorily until I had a small stroke and lost strength in my arms, wherein I started using Metro-mix, a prepackaged soil mix. Despite the seemingly high price it works out to 23¢ per flat which holds 96 plants. We use a dilute Peter's fertilizer, using a M. P. Mixer-Proportioner in a constant-feed feeding schedule.

It usually requires 7-8 months from the time we insert the runners until the finished product is available. We charge for 90 plants so as not to have to count the plants in each flat. When we plant a flat it is watered in with fertilizer water and covered with a plastic bag for 2-3 weeks. Having been placed in the shadiest lower bench, it is moved upward when uncovered and ends up on the top bench prior to delivery.

All shelves in the culture room and greenhouse are washed between crops with Physan @ 9 75 ml/3 liters of water and periodically the greenhouse side-walls are also washed.

Running this profitable tissue culture lab has been a very worthwhile endeavor, climaxing 40 years of growing. I regularly review over 40 technical journals at Cal-Poly in Pomona, copying those articles on tissue culture and card indexing same. We feel that our achievements in tissue culture is due to our life-long interest and hobby in plants. One of our customers in Anaheim is starting his own lab under our training.

OVERVIEW OF TISSUE CULTURE AT K. M. NURSERY

JIRO MATSUYAMA

K.M. Nursery

Carpinteria, California 93013

We, at K M. Nursery, have been involved in tissue culture since 1969. We have met and talked with many researchers and commercial producers from almost every country in the world about the problems we have encountered.

The foreign countries are working on mostly vegetative crops, such as those grown for paper pulp and number, especially in the smaller countries, while in the United States it seems we are producing mostly ornamentals commercially, although much research is going on in tissue culture of herbaceous crops So it will not be very long before many of the important herbaceous plants will be produced through tissue culture

Many nurserymen do not understand propagation by tissue culture although many articles have been written and talks have been given by speakers on this subject. Many people think tissue culture is as simple as mixing some media formula for all cultures, then placing shoot tips in a test tube and culturing it in an ideal room temperature and in a few weeks having sizable multiple plantlets. This is wishful thinking. It takes many man-hours of research for each species and cultivars that you are going to culture for commercial production, especially for hardwood plants.

When first starting commercial production sanitary conditions aren't a problem as laboratory equipment and the culture room are new and easily kept clean. But as time goes on, in mass propagation contamination will appear.

I have always said research is one thing that we all need.

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Commercial production is something else when tens of thousands of cultures are involved every day.

In January, 1975, we were able to get started in commercial tissue culture production in our own laboratory, with the help of Dr. Toshio Murashige of the University of California, Riverside, who was instrumental in getting us started. Without his help, advice, and encouragement we couldn't have gotten started or come as far as we have.

All tissue cultured plants produced in our laboratory are transplanted into 1-gallon, 5-gallon, or 15-gallon containers to be sold as outdoor landscape material. Any excess we produce is sold as 2¼" pot liners.

In over five years of commercial production, we are constantly doing research to see if we can get better multiplication, a superior rooting system on woody plants, with quicker and better ways of hardening off.

Most laboratories are producing indoor house plants. With these there are not many problems compared to woody landscape plants. First of all, in woody plant you have contamination from the soil This is natural because they are grown directly in or on the soil, while house plants are grown indoors and isolated from the ground, so there is less chance of contamination.

Woody plants are more inconsistent in the multiplication stage than soft wood materials. Many times contamination is within the tissue itself, which makes it harder to clean during culturing. There are times when the disinfection process has to be repeated 3 to 5 times to get the material clean. The best procedure is to isolate the mother stock plants off the ground — kept indoors if possible. Keep it under drought condition and irrigate only when needed and from the bottom only. By doing this for 3 to 4 months there is a better chance of getting a clean culture. Contamination during culture has to be watched closely. It is easier to prevent contamination than to control it after infection. This is not only viruses and bacteria but includes thrips, mites, web gnats, etc. Some of these insects are so small and transparent that it is almost impossible to detect them without a 25× power microscope.

Next, rooting is a problem on hard-woods. But it is just a matter of time before it will be solved.

I think the major problem, at the present time, is the hardening off after rooting in the liner stage, before it goes out to the outside environment. Humidity, temperature, light, mist control, rooting, fungicides and fertilizers, have a lot to do with survival of the plants.

Media — originally, we were making our media from

scratch. Later, we started to buy pre-mix media to save time and labor. For a while it seemed like a good pre-mix, but later we started to see some difference in the growth of some cultures. So we did some tests and found that the company had forgotten to include some chemical in the pre-mix or they had substituted some chemical with inferior products After our tests we decided to go back to making our own media.

We have cultured many plants species. But, for reasons of costs, in time and labor, we have found that the conventional method is the better way for propagation of some species of plants.

Commercial production of the following species has been accomplished:

Agapanthus 'Mood indigo'
Anthurium
Ophiopogon planiscapus 'Arabicus' Black mondo grass
Ophiopogon japonicus, Dwarf mondo grass
Clerodendron thomsoniae
FERNS
- *Adiantum raddianum* (Syn *A cuneatum*)
- *Alsophila australis*
- *Aspidium capense* (*Rumohra adiantiformis* ? Bot ed)
- *Davallia trichomanoides*
- *Dicksonia antarctica*
- *Nephrolepis exaltata*
- *Woodwardia fimbriata*

Ficus benjamina
F decora
F decora 'Burgundy'
F pandurata
Hemerocallis 'Aztec Gold'
Howea forsterana
Nandina 'Royal Princess'
Nandina 'Compacta Nana'
Nerine
Photinia × *fraseri*
Sequoia sempervirens
S sempervirens 'Santa Cruz'
Simmondansia chinensis (Syn , *S. california*)
Tupidanthus calyptratus
Zanthoxylum piperitum

MODERATOR BRUCE BRIGGS: We have time for a few questions. The first is for Dr. Cheng.

VOICE: How do you obtain your explants for your tissue cultures?

TSAI YING CHENG: Tree species are very different from herbaceous plants. What we do is to provide enough chilling treatment and then bring the stock plants into the greenhouse and force them to break dormancy. Then we force the new shoots to grow very rapidly and then we take these shoots for tissue culture use. Now, after we remove the shoots from rapidly growing trees, we remove the leaves and cut the stems into appropriate sizes and then sterilize with Clorox. Then we put them into a conditioning medium because most of the stem pieces we obtain from trees, even after Clorox treatment, are often still contaminated with microorganisms. So, by having this conditioning step, we can eliminate all the contaminated ones, and just choose clean materials for shoot multiplication. Also

under these conditions we try to treat plant materials in such a way that they are homogeneous so that when we put them into the shoot multiplication stage they give us a more homogeneous type of response. In addition, when you have plant materials under tissue culture conditions, often you don't have to put them in shoot multiplication medium right away. You can maintain them in a conditioning medium and hold them for a time. It is a convenient step for us. Therefore, in the preconditioning treatment we use a basal medium which contains very small amounts of auxin and cytokinin. I am talking in terms of something like ⅒ of 100 ppm of IBA and BAP. Or we put them in the basal medium without any hormones and later transfer them into a medium containing hormones, depending on the plant species or cultivars. We have to decide which is the best method to use. The conditions for the preconditioning treatment are 16 hours photoperiod, 200 foot candles, and 20°C temperature.

WES HUMPHREY: Jiro Matsuyama, you showed a slide of *Howea forsterana*. You are doing some work on that in tissue culture with some success?

JIRO MATSUYAMA: The reason I am working on *Howea* is not to get multiplication; it is to cut down on seed germination time. It is embryo culture. I can save 50% time on germination. You have to know the correct time to excise the embryo. That is the trick to it. You don't wait for the seed to get ripe. The older the seed the harder it is. Doing embryo culture in the culture tube is one thing, but getting it out into the light is another story. It is real hard. We are working on it right now. We have quite a bit of it going, as far as that goes, in the culture tube. Getting the seedlings into the outside is the problem. I think that is what most of the production people are having a problem with.

LES CLAY: Dr. Cheng, have you had any experience in working with the Japanese maple?

TSAI YING CHENG: Well, grafting and budding — yes. You are asking a question that I am not supposed to answer. Since you ask the question, I work for the Oregon Graduate Center and my personal interest and the Center's interest has to be differentiated very clearly. Japanese maple has been my interest for years. Since I am doing tissue culture at the Center so what I can do with Japense maple is to try to improve the conventional methods. I am doing cuttings, grafting, budding with Japanese maple with quite successful results. But tissue culture, I have to talk to the Center to get approval before I can do it.

VOICE: What type of gibberellic acid was used in your work?

TSAI YING CHENG: I use GA_3 at 10 ppm. With maples we have to make sure that the cytokinin is on the lower side. The

high side is inhibitory, the proper balance of the three hormones (auxin, GA, and cytokinin) is very critical.

BRUCE BRIGGS· You say that cytokinins for Japanese maple should be on the low side?

TSAI YING CHENG: I would say about 0.1 or 0.2 ppm. The maple is a very striking example of the GA effect. It is so clear cut. You can see it in one week, with or without GA_3. It is very clear cut.

BRUCE BRIGGS: The problem you get into with GA is that you stimulate a plant but then you find it hard to put roots on the other end similar to what we have in cuttings. We sometimes had to quit using GA on plants because the cuttings didn't root. I am sure through tissue culture we will solve this problem — either through light or temperature or through a rest period or someway where we can destroy the GA and get some roots to develop

VOICE: Jiro, are you having good results on all of your redwoods, or is there a difference among cultivars?

JIRO MATSUYAMA: Well, mostly it is still in the research stage. I don't call it actual production yet. It doesn't come out the same all the time; we raise quite a few, but still I call it research. I am working with *Sequoia sempervirens* 'Santa Cruz'. So far it seems like it is pretty successful, But I can't say yet. A lot of these plants may be worth propagating through tissue culture. If it isn't we just quit. We do it through the conventional method of propagation; it is a lot easier and cheaper

RALPH SHUGERT: Tsai, I have two questions on Norway maples. One, does it make any difference what the explant is? Are you taking stem or leaf, whatever? Number two, after you get the rooted shoots, what about the stage until the nurseryman plants it out in the field as a one year liner? How are you handling that?

TSAI YING CHENG: The second question, I cannot answer very well because I am not involved in the commercial end of it. Maybe Bob Ticknor can answer you second question. The first question; we prefer to use stem explants. Even using stems we got lots of contamination. In using leaves, they are more tender when you go through Clorox treatment so you get lots of bruises So we prefer to use stems and, if necessary, at the conditioning stage we force the stems to produce other shoots, so will have new stems and leaves from there.

RALPH SHUGERT: So you are taking one year wood, really?

TSAI YING CHENG: Yes, the stem will be new growth.

RALPH SHUGERT: Does juvenility enter into this?

TSAI YING CHENG: Because all the trees are mature, I am not sure that they return to juvenility.

RALPH SHUGERT: OK, now how about the handling of the stock plants?

TSAI YING CHENG: Well, I got my maples from McGill Nursery. They gave me small size trees — just big enough to put in the greenhouse.

RALPH SHUGERT: Would it be a one-year whip, a one-year bud?

TSAI YING CHENG: Yes, about one year. I don't want to handle big trees. Small ones are much easier for me. Sometimes I cut the terminal buds off, and strip all the leaves to force the lateral shoots to grow. I take new growth from these.

BRUCE BRIGGS: Martin Crehan, you have been doing quite a lot of literature research on tissue culture propagation and keeping data on new plants and new material. Are you keeping up with the literature right now? You might like to comment on what you are doing in this area.

MARTIN CREHAN: I am located close to the California Polytechnic University at Pomona; when the idea first came to me, I did all of my studying at Cal Poly LIbrary. It is just a hobby with me. I copy most articles that are found in about forty different publications that are available at the Cal Poly Library. I xerox them, bring them home, and index them; I have a buddy up at Carpenteria, California, and I usually send them up there to him. He xeroxes what he needs in his lab and sends them back. We have numerous visitors and, believe it or not, they are from all over the world, from Taiwan, Australia, and New Zealand. When the American Society of Horticultural Science Conference was at Fort Collins, Colorado, we had three Ph.D's stop in during one day Most of the students at Cal Poly that want to do senior projects in tissue culture will come over and copy a lot of the reference work. It is really just a hobby with me, but it is a seven year collection, so far. I am starting to run out of file cabinets.

BRUCE BRIGGS: If we were to write you about some particular work that you might have information on, would you answer?

MARTIN CREHAN: Yes.

BRUCE BRIGGS: So, you members that have some new plant and are looking for some new data, here is a source of information.

Now, I would like to have all three of you comment on this problem. Do you feel we may have a problem in genetic breakdown in tissue culture? If we do have such a problem, how are

we going to solve it? I am talking about genetic variation — crooked leaves, stems, and such things that people don't like to see appearing in asexual propagaiton. We want to have a plant that comes true to name.

TSAI YING CHENG: Yes, I am very concerned about it. So what I suggest, perhaps, is to use hormones at the lower concentrations, because we know that to use high hormone concentrations you tend to induce a change in the chromosome numbers. Second, try to bring in new materials as often as you can so make sure you are not continually propagating a mutant.

MARTIN CREHAN: Bruce is talking about mutations. When we first started working with tissue culture, we ended up with the most beautiful mutations you have every seen. I have a bank in back of the greenhouse I built up with those mutations. When the problem was referred back to Dr. Murashige then, it was found out that in the second stage, the multiplication stage of the ferns, we were causing mutations. The recommendations then were that we could repropagate in tissue culture five, six, or seven times, but research at the University showed that the problem was alleviated by repropagating during the second stage only three times.

BRUCE BRIGGS: I think that Dr. Cheng did some work a while back — it is reported in the *Proceedings* — where she showed the chromosome counts didn't vary too much between tissue culture and normal propagaiton, which might be some indication. Have you changed you mind on that, Tsai, or have you checked anymore chromosomes?

TSAI YING CHENG: I haven't checked, but we have transplanted many tissue culture plants into the greenhouse and morphologically they look very good.

BRUCE BRIGGS: Jiro, on the same subject then, can we go the other way? If you are studying a new plant, you may have better results if you use cytokinins at a very high level so you can get shoot development, which means you get more shoots. But in the process of doing it there is the possibility of more mutations. Now, do you feel that we would be better to start off that plant slow, or would it be better off to go high in the cytokinins to get more shoots and then take it down to a low level. Or is there any difference?

JIRO MATSUYAMA: Well, when you are first starting out on tissue culture, you can use about six different kinds of media. Variations can occur; watch and see what happens. We try to get the minimum callus possible, but get roots to form. That is the main thing. If you get too much callus, you get too much root but then you know there is no top to it. The main thing is to have

shoots and roots. Shoot multiplication and rooting too. You have to have both.

VOICE: Has anyone produced fruit trees successfully by tissue culture methods?

TSAI YING CHENG: Well, the fruit trees I worked with was on understocks, not fruiting cultivars.

BRUCE BRIGGS: Dr. Anderson at Mount Vernon, Washington, has 'Red Delicious' in tissue culture; he is working on a project with several of the spur-type sports. At the present time, I am not sure that he has any tissue-culture grown trees back to the grower but he does have them growing. He has a rooting problem with the shoots, but he is working on that. They do not respond as well as the rootstock types. But I know that they are going to solve this problem.

ARDA BERRYHILL: Jiro, you mentioned that some things you grow are more suitable by conventional propagation than by tissue culture. Out of curiousity, could you mention those that you find more suitable for conventional propagation than by tissue culture?

JIRO MATSUYAMA: Well, like I said before, *Photinia* × *fraseri*, is one You can grow that by tissue culture like a weed, but it is not worth it. If you propagate by conventional methods, it is just as easy. You can get all you want.

ARDA BERRYHILL: It is a matter of economics.

JIRO MATSUYAMA: Yes, that's right.

VOICE: Jiro, could you elaborate on what you said on variations in the sequoia? What were the variations that you saw?

JIRO MATSUYAMA: What I meant was that you find a mother stock tree with a lot of close nodes, good tree shape, and then you try to tissue culture from that strain.

RALPH SHUGERT: Bruce, has anybody tissue-cultured *Taxus*?

VOICE: I think in France they are working with *Taxus*, yellow pines, and cedars at the Phytotron just outside Paris.

RICHARD SMITH: Dr. Cheng, you mentioned the virus load in certain woody ornamentals you are working with. Have you made any attempt to free these plants of virus?

TSAI YING CHENG: Yes, but I haven't looked at the end results yet I have been taking shoot tips and recycling them in the tissue culture. They seem to be more vigorous but I haven't looked at them under the electron microscope or used any indexing method so I cannot tell you clearly that they are free from viruses. But they should grow vigorously.

BRUCE BRIGGS: Is Dr. Harris here from Victoria, B.C.? He has been working on grapes; last year he ran about half of his grape cultivars through tissue culture and repeating the process, he felt at that time they were free of those viruses that he could identify. It would be interesting to see whether we can do this with all woody tissue, but it was done on grapes — and it is promising.

KIWIFRUIT PRODUCTION

W. H. BROKAW
Brokaw Nursery, Inc.
Saticoy, California 93004

INTRODUCTION

Of all the recently introduced subtropical crops, none has caught fire like the kiwifruit or Chinese gooseberry, *Actinidia chinensis*. Not an old warmed-over crop, or one that's been hidden in the corner, this one is a real newcomer. Since its commercial introduction by New Zealand, it has been grown commercially in the Western and Eastern United States, other American countries, Israel, Greece, Italy, France, South Africa, and Japan.

Actinidia chinensis is native to borders of the Yangtze Valley of China where it is not subject to serious frosts, but receives enough winter chill to stimulate profuse blossoms. The wild plant of these regions is a large vine that may climb to a height of 30 feet (10 m). Until recently, its popular name was *Chinese Gooseberry.*

The *Chinese Gooseberry* was brought to New Zealand about 1900, and planted as a curiosity. It remained in obscurity for years, until the New Zealanders developed certain prolific cultivars which bore abundant, highly edible fruit. The most famous of these, and the current standard, is the 'Hayward.' By the 1960's, New Zealand growers exported Chinese gooseberry fruit to the United States. About 1974 they adopted the name "kiwifruit" — presumably because of the brown hairy exterior, reminiscent of their native national bird, the kiwi.

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The Tanimoto Brothers of Gridley first propagated kiwifruit commercially in 1964. They had heard of imported Chinese

gooseberries selling in San Francisco for $1.50 per pound Conversation with their University of California Farm Advisor led them to horticulturist Bob Smith, at the USDA Chico Station, who furnished them with advice and propagation materials from the "mother vine" at Chico and from the Chico male vine Fortunately both Chico vines turned out to be superior and complementary cultivars for commercial production in the Sacramento Valley. The mother vine cultivar is now known as Chico Hayward.

VINES AND FRUIT

Kiwifruit vines are vigorous and large. Single vines can become the size of large orange trees. Their dark green leaves are roundish, flat, and 10 to 12 inches across. The plants are divided into sexes (the species is dioecious) so that male plants are staminately fertile; female plants are pistillate fertile. Normally only female plants bear fruit, though hermaphroditism has been reported.

Usually deciduous, the kiwifruit vine sometimes fails to complete dormancy in certain warm winter locations. If winter chilling is insufficient, leaves may become tattered and burned at the margins, and remain attached to the plants for long periods.

Climatic limitations for the kiwifruit are not stringent. Fine kiwifruit growing areas in California include the Central Valley, the hills around Ramona in the South and Red Bluff area in the North. These areas are normally free from severe freezes either during March, April, and May when kiwifruit vines are producing spring shoots and flowers, or during October and November when the vines are carrying unharvested fruit. Yet, these areas are cool enough to fulfill the chilling requirements. Nobody really knows precisely what are the chilling requirements. We only know that the Central Valley normally provides correct conditions for the most popular cultivars, whereas the balmier coastal regions of Southern California do not.

Lack of frequent strong winds seems to be another requirment for kiwifruit culture. An abundance of high quality water must be available for proper growth since the kiwifruit's shallow, fibrous root system has become adapted to heavy rainfall areas. It is essential that sufficiently extensive ground areas be frequently and abundantly watered and that the soil have efficient internal drainage qualities.

Kiwifruit vineyards are not troubled by many serious pests. Occasionally, though, they are visited by scales and moth larvae. Crown rot is sometimes a problem when high temperatures and wet soil coincide. Crown rot in young vineyard plants has been attributed both to *Phytophthora* and *Rhizoctonia* species.

The most popular cultivars have fruits about the size of

goose eggs, with stiff hairs about 1/16″ long extending outward from the brown skin on all surfaces. The interior flesh is bright green in color, translucent, and dotted with hundreds of tiny, dark, edible seeds. Its flavor has been compared to that of the strawberry, pineapple, melon, guava, and so on. Fresh fruit may be stored at 6°C (43°F) for at least six months. Kiwifruits are useable in many ways. The fruits can be peeled and eaten out of hand, or served as slices in salads and in fruit desserts. They may be frozen or canned. They make tasty prêserves or jam Additionally, a thoroughly acceptable kiwi wine is now on the market.

VINEYARDS

Commercial kiwifruit vines are large and bear heavy loads of fruit requiring the support of a very sturdy trellis system. Generally trellises are of the "T"-bar type, most commonly constructed of vertical members of lodgepole pine, 5″-6″ in diameter, that rise to 6 or more feet above the ground. Crossarms are 6 feet long and horizontally mounted at the top of the vertical member. These trellises are braced and set at 20 foot intervals in rows that are about 15 feet apart from center to center. Five wires are stretched tightly on the crossarms of the trellises from the ends of the rows. A kiwifruit vine is planted by each trellis.

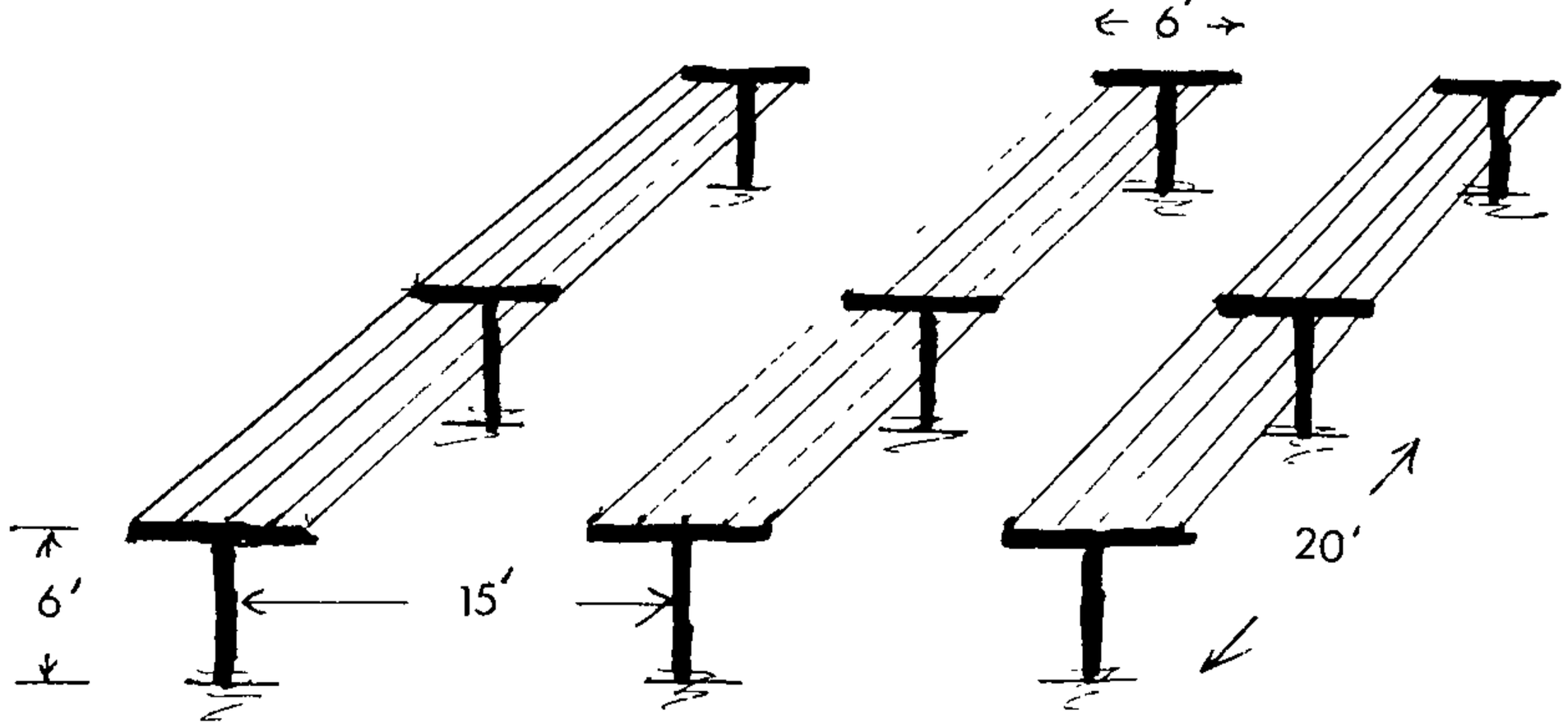

Figure 1. Diagram of typical five-wire T-bar trellis system used for kiwifruit

Female plants outnumber male plants eight to one in most commercial plantings. There is no sacred ratio but one male to eight females is standard practice.

The most time consuming operation in any vineyard is pruning. Each winter, growth is cut back allowing fruiting wood to remain for the following spring. In addition, summer pruning is performed to provide proper illumination of the vine's interior.

PROPAGATION

California commercial propagation has a history of only 15

years, and the methodology is in a state of flux. Most propagation has been for the purpose of providing vines for commercial plantings.

California kiwifruit vines are normally grown either as grafted seedlings or rooted cuttings. Grafting of seedlings is the most popular method as it is easy and dependable.

Grafting of seedlings

Raising the seedlings: At Brokaw Nursery, Inc. we normally sow the tiny kiwi fruit seeds (about 1 teaspoon per flat) in the hothouse during January, February, or March. The seeds have been previously extracted from commercial fruit of any standard cultivar. Extraction is done by hand, which is very laborious, or by machination of the fruit in a blender and subsequent separation from the pulp through a strainer. The equivalent of stratification may be accomplished either by: (a) layering the seeds in damp sand in a refrigerator for three weeks, or (b) leaving the surface-dried seeds in plastic bags, removing them from the refrigerator during each day and returning them each night for a period of three weeks. These "stratification" procedures are for the purpose of breaking dormancy, a condition which often afflicts the kiwifruit seeds soon after they are extracted from the fruit.

About a month after sowing, the young kiwifruit plants are growing thickly A few will be ready to transplant bare root, into small pots. We normally plant them either into Jiffy #7's or into small plastic bags filled with a peat-perlite blend. After the plants in Jiffy #7's have established roots, we transplant them outside into three gallon plastic containers for later grafting. Sometimes we hold the small seedlings planted in the bags and graft them in the greenhouse

Grafting — (inside the greenhouse in small plastic bags): I understand that some nurserymen "green-graft", which is grafting scions onto green succulent seedlings in the hothouse. Personally, I have not succeeded with this method. We graft by using a whip- or wedge graft after the main seedling stem has matured and hardened. For this, we use dormant, or firm green, scion wood. After the scions have knitted and grown to a five or six inch length, the young grafted plants may be transplanted into larger containers.

Grafting — (outside in three-gallon container): Plants that have been transplanted into large containers (1 gallon or more) in the spring may be whip- or wedge- grafted, or budded the following September or October, or the next April or May. Fall grafting may be accomplished either with dormant scions from the prior winter or with firm green fall budwood. For spring

budding one may use dormant buds stored from winter gatherings.

Sometimes nurserymen graft during winter, using dormant scions. If one does this, it is wise to use local scion sources only, as it is essential that the grafted scions do not break dormancy before the rootstocks do or before the callusing (healing) process is under way.

Grafted seedlings make fine plants and are preferred by many vineyard owners. They have two possible deficiencies: (a) uncontrolled rootstock shoots may outgrow the scions; and (b) in case of a strong freeze the plant may be frozen to the ground, thus killing the wood to a point below the graft union. In the latter case, subsequent regrowth of the rootstock can be regrafted with new scion wood.

Rooted cuttings

There is a common opinion that New Zealand nurserymen find it very fast and efficient to root cuttings, but believe that the more troublesome grafted seedlings are superior.

Both hardwood and softwood cuttings have been attempted in California. While there are a few reported successes with winter hardwood cuttings, most positive results have been with fairly young spring, summer, and fall softwood cuttings. One, two, and three-noded cuttings have been used, with a single leaf (often trimmed) attached to the upper node. Mist may be applied. Hormone dips (IBA at 6000 ppm is standard) are normally applied.

A common problem with the rooting of cuttings is that the foliage buds often precede the emergence of roots. The ever-abundant callus tissue is said to inhibit root initiation. Perhaps this could be controlled by heating the rooting medium while retaining a chill in the moistened atmosphere above the rooting medium.

Another problem seems to be that the leaves are prone to abscise before the buds sprout. The cuttings then act as if they are going into dormancy.

Some growers report that the root systems of cuttings are inferior to those of seedling rooted plants. However, the few cuttings that we've grown at Brokaw Nursery, Inc., seem to have satisfactory root systems.

GROWING THE PROPAGATED PLANTS

At Brokaw Nursery, Inc., we sell a grafted plant that is about 15 months from seed. It consists of a single long vertical shoot, five feet long, with a leaf at each node, trained to a stake. Its caliper is about ½ inch.

The most troublesome part of growing such a plant is the training of the scion to climb straight up its own stake. Being a vine, the fast growing tip forever seeks neighboring stakes and winds around them Therefore, one has to be always correcting the vine with training ties of some sort Further, before the vine reaches the top of its stake, it often slows its growing so that the tip begins to twist and "corkscrew". When this happens, a common remedy is to cut the leaders back to pencil-thick wood. In three or four weeks, a strong axillary bud will assume the function of the former growing tip.

TIMING FOR VINEYARD PLANTING

Since kiwifruit plants are deciduous, many excellent vines are delivered bareroot. They are grown in nursery rows, dug during the winter, and planted during the winter or spring. They may be stored for a time under refrigerated conditions.

Containerized plants, such as ours at Brokaw Nursery, may be planted at any time during the year Kiwifruit plants are precocious and vines that are planted in October may bear a few mature fruit one year later.

THE POTENTIAL FOR GARDEN KIWIS

Kiwifruit vines are popular among homeowners because of their novelty and the fact that nearly everyone likes the fruit the first time he tries it The vines are attractive but must be provided with robust support and ample space. Some people design arbor systems, which can be utilized for shade in the summer and provide an open latticework protection during the winter.

I have not yet seen anyone espalier kiwifruit though it seems possible.

Incidentally, young kiwifruit plants are attractive ornamentals indoors. A few years ago we produced "Kiwi Pairs" (male and female) in an attractive six inch pot. They were sold as an item to grace the interior of the house temporarily, and later to be transplanted outside. Though very attractive and popular, they had a survival problem. The indoor plants were exceedingly tender when transferred out of doors, and home gardeners consistently lost them.

CULTIVARS

Two commercial cultivars are standard in California. the 'Hayward' and the 'Chico Hayward'. They produce abundant crops of ovoid fruit. Both cultivars have a fine flavor and produce good sizes (3 to 5 oz.) in most California districts.

Some of Southern California's coastal districts provide too

little chilling for these standard cultivars and in these areas it is best to use one of the following alternatives:

'Bruno' — this is a New Zealand cultivar with somewhat smaller fruit of a long narrow shape. The vine is quite prolific.

'Vincent' — This cultivar is from a seedling of Fred Vincent, propagator in balmy Yorba Linda. The abundant fruit, somewhat smaller than 'Hayward,' has been very acceptable to Mr. Vincent's local customers.

Two male cultivars are in common use in California. They are 'Chico Male' and 'Matua.' While there has been some complaint about their blossoming periods, both seem to be more than satisfactory under most commercial conditions in California.

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MINIATURE ROSE PRODUCTION

RALPH S. MOORE

Sequoia Nursery Co.,
2519 East Noble Avenue
Visalia, California 93277

The propagation and sale of miniature rose plants has been our business at Sequoia Nursery for many years. During these years many changes have taken place, as has happened throughout the nursery industry. First of all has been the phenomenal increase in popularity of the miniature rose.

Beginning with miniatures in a small way, as a side line to our general nursery some forty years ago, we changed to the production of miniatures exclusively about 23 years ago. Since then our production has increased to the point where we now grow some 600,000 to 700,000 plants annually.

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All of this production is from cuttings. We grow around a hundred different cultivars in all colors. In addition we produce around 10,000 miniature tree roses. For the trees we use an understock of our own, developed at the nursery. I will discuss the tree rose production in detail later.

But before we get into the propagation of miniatures as such, I wish to state that I am very much of the opinion that successful and economic production first of all stems from the breeding. Since all our production is by cuttings one of the first prerequisites is that a cultivar must lend itself to easy and efficient rooting. This is no happenstance so, from the beginning, my breeding efforts have been directed to the development of new and better cultivars of miniature roses into which I have bred this desirable quality. In addition, any new cultivar should be at least as good as other cultivars in the trade insofar as flower quality, color, plant growth and habit are concerned.

There is also the need for certain special purpose cultivars, for example: those suited to growing in warm climates or in cold areas. There is need for kinds which by their very nature, singles (5 petaled), ground cover, unusual, or novelty colors, climbers, etc. may not attain any great sales, yet can add considerably to the total production and sales.

Many of the European originations have in the past been, on the average, more difficult and slower to root. This I am sure was the result of either not giving this factor of easy rooting sufficient concern or that suitable cultivars for breeding this quality were not available to the European originators. Some of this lack is now being overcome partly because some of my own cultivars are now being used by overseas breeders.

Going back in time to my earlier years, I determined that certain species and cultivars had the easy rooting qualities I wanted. Among them the species, *Rosa wichuraina* (from which the famous ramblers were developed), *R. multiflora* in several forms and hybrids, certain of the older roses, especially some of the polyantha roses, some of the cultivars called "Sub Zero" roses developed by the late W.D. Brownell, and some of the "Kordes" cultivars bred by Wilhelm Kordes of Germany.

From such roses, plus several of my own hybrids as the basis for breeding, I have proceeded to make crosses in various combinations with the miniatures to develop the many cultivars we now grow. But without adequate planning it is easy to lose some of this ability for easy rooting and so new crosses are carefully planned to retain and to enhance ease of rooting.

Ease of rooting is an economic factor we cannot overlook, whether we are growing pyracanthas, geraniums, or roses. A quick rooting plant will usually take less time from sticking the

cutting to sale of the finished plant. With the increasing cost of heating, labor, etc., it only makes sense to get the plant on its way as fast as possible.

Important also is the development of the most desirable cultivar(s) as to shape and branching habit, one which shapes itself saves in shearing or pinching. Also, a naturally bushy miniature rose plant will produce more cuttings than one which tends to grow open and leggy.

If a mother (stock) plant of cultivar 'X' will produce 25 cuttings and another cultivar 'Y' will produce 50 cuttings in the same space and time, we can no longer grow 'X', and if the new cultivar 'Y' will root quicker with a higher percentage of plants it is easy to understand why I contend that one of the important factors of successful propagation and growing is first of all in the breeding.

And so we begin our propagation with the selection of cultivars to be grown. Of course, we all want to grow plants which can be sold in the market place, hopefully at a profit.

The kinds to be propagated must have sales appeal. They must have color and other qualities which the buyer wants. So first of all we must grow a saleable plant.

Desirable qualities which we must always keep in mind when making up any list to be grown are. ease of rooting, availability of cutting material, resistance to disease problems, general good looks of the plant, and cost of production. We can sum up our list of desires in two words (1) *Growability* and (2) *Saleability*. So we select the best cultivars to be grown. Now we must get down to the actual "dirt gardener" approach, and that is what I now want to share with you.

We have bred or developed our cultivars. Many of the better cultivars on the market today are protected by plant patents and it is unlawful to propagate them without permission (license) from the patent owner. So we select the kinds to be grown from our own patents or kinds for which we have license from others to propagate, plus certain of the older kinds and/or newer ones which for some reason were never patented.

We also must decide the colors or color balance we need to grow and in what quantities. Propagation of certain cultivars may be limited by quantity of cutting material available. But over a season's time this is often leveled out because we propagate all year.

To make this paper more specific, I will now attempt to go through a complete growing cycle. Cuttings are generally taken from plants growing in one or two-gallon plastic containers. We use these containers for several reasons:

1) It is a good size for growing and handling.

2) Plants can be moved from place to place easily; for example, we grow much of our cutting material in the plastic houses. Plants grow faster, thus producing more cuttings in a given time. But it is also desirable to move plants outside to rest and recuperate periodically. We can then use the space to better advantage for other cultivars as needed to produce the total desired quantities of cuttings.

3) As we add or discard cultivars it is much easier to do so if they are grown in pots.

Cuttings are generally made with two or three nodes, of rather soft to semi-hard wood. Leaves are left on. During the winter we often use hard or mature wood, mainly because we have it. Rooting of the harder (more dormant) wood is much slower. All cuttings are rooted outdoors in the warmer parts of the year (April through September). The leafy soft to semi-hard cuttings will root in 3 to 4 weeks; often in warm summer weather rooting will occur is as little as 2 weeks. On the contrary, during the winter months (outdoors) it may require up to 8 or 10 weeks

As cuttings are made they are dropped into a plastic bucket or pan and then dipped into a solution of Orthocide (1 tablespoon per gallon of water). Cuttings are then taken to our growing benches (tables) and stuck directly into the pots. Our growing/rooting mix is made of 1 part fir bark, 1 part perlite, and 1 part peat moss. Our bark is ⅜ to ½″ screen size

We found that a finer grind bark, due to the high percentage of very fine material plus the fine particles of peat moss resulted in too much water retention and it gave us problems. The growing mix gives best results if it is on the slightly coarse side to insure adequate drainage and aeration. To this mix of bark, peat, and perlite are added trace elements and other materials to grow a satisfactory plant. We also include about seven pounds of Osmocote per cubic yard.

Pots are placed on our growing tables or in nursery flats and filled with the growing mix above. Cuttings are stuck (one per pot) not over 1″ deep, preferably ¾″, with all leaves left on. Soft tips or flower buds are removed. Cuttings must never be allowed to dry, as soon as flats or a section of the bed is filled, the mist or sprinkler is turned on. These are allowed to run from early morning to evening in hot summer weather with the time cut or modified as needed depending on heat, length of day, wind, etc.

Part of our operation is under mist controlled by time clocks. Most of the area is watered or misted by "L" head sprinklers made by Perma Rain of Lindsay, Calif. These were designed for use in citrus groves but we have found them very satisfactory in

our operation. To get good coverage we place each sprinkler on a pipe riser 12″ high (some higher) down the centers of 6 foot wide tables. Sprinklers are spaced about 7 feet apart (some of the earlier installations were further apart but should water pressure be low, or the day windy, coverage is not as good as desired). We modify the plastic tip of each sprinkler by making three small cuts across the inside of the tip to spread or "fog" the water better. Mist heads are on 12″ risers, spaced 30″ apart with two lines on each 6′ table.

After rooting has occurred we top dress the beds or flats with any one of several fertilizers. We may spread dry material (Osmocote) or apply liquid fertilizer as desired. At any time after rooting we may pick up plants and place them in a plastic house where the young plants can be forced into more rapid growth. This is one of the reasons for rooting cuttings all year long.

If we are short of a given kind but have well rooted cuttings they can be moved inside for more rapid growth. We usually feed with two or three applications of liquid fertilizer at half recommended strength at 7 or 8 day intervals. Handled this way, we can finish off young plants in 6 to 8 weeks in the spring, having good plants available for late spring sales which otherwise, if left outdoors, might not be saleable until fall.

To make or keep plants more bushy we shear as needed. If carefully trimmed, the plant is improved and we can get a good quantity of fine cutting material. This is especially useful in propagating sufficient quantities of new cultivars. Sales of miniature rose plants goes on over most of the year and so having plants in varying stages of growth is really better use of facilities as young plants of good quality can be made available as needed.

The time necessary from cutting to saleable plant will vary considerably depending upon such factors as cultivar, size of pot, time of year, whether grown (or finished) in the greenhouse, etc. We do not like to really "force" our plants but prefer a slower sustained time of growing. Even the plants we may move into the greenhouse to finish off in the spring are usually allowed to harden off some before shipping. This is mainly the reason for applying the two or three light applications of liquid fertilizer. It allows the growth to respond quickly as needed and then to slow down as the fertilizer is used up.

To sum up our miniature rose production:

1) To assure ease and rapidity of rooting we breed these qualities into our new cultivars. This makes for rapid and economic production.
2) We select what we feel are the best cultivars from our own and other breeding.

3) We discard or drop cultivars which have been superseded by newer or better kinds.

4) Types of cuttings: we make cuttings 2 to 3 nodes long (the general rule) but may also, if material is available and plants are needed quickly, use branched (2 to 3 stem) cuttings. Cuts are made directly below a node.

5) Cuttings are never allowed to dry out; they are dipped in a fungicide solution, drained, and stuck as soon as possible.

6) All cuttings are dipped in a Hormex rooting powder.

7) Cuttings are misted during the daytime until rooted.

8) Growing/rooting mix: 1 part peat: 1 part fir bark; 1 part perlite.

9) Beds or flats of pots are top dressed with fertilizer as needed.

10) Time from cutting to finished plant varies depending upon pot size, time of year, weather, fertilizer, in or out of greenhouse. Normal time (average) is 6 to 10 months.

11) Mother plants are grown in 1 or 2 gallon plastic pots.

MINIATURE TREE ROSE PRODUCTION

To grow our miniature tree roses we start with the understock cultivar which, in our case, is 'Pink Clouds.' It originated with us as a cross of 'Oakington Ruby' (miniature) X *R. multiflora.* It grows very much like *R. multiflora* but the long canes are nearly thornless, dark green in color with excellent leathery foliage. We have tried several other understocks but come back to 'Pink Clouds.'

Cuttings are made about 16 to 17 inches in length, averaging about pencil size. Each cutting is de-eyed, leaving two leaves at the top. We have found that 'Pink Clouds' roots better and quicker if leaves are left on. Cuttings are then scored with a Multi-Rooter tool (cuts four 1″ vetical slits (wounds). This hastens rooting and gives a better balanced root system.

Basal ends of the cuttings are then placed in water (1″ deep) until they can be planted. Each cutting is dipped in Hormex powder and stuck into a growing mix in 3″ square plastic pots. Constant mist has given best results for rooting tree rose understock. We use these pots as more fit into the rooting bed and, when rooted, plants can be transferred to 5″ pots to grow on. As soon as good growth is underway these understocks are budded to the desired cultivars of miniature roses

When the buds have "taken" most of the 'Pink Clouds' top is cut back (later completely removed) to force the buds into

growth. As each new shoot becomes 2 to 3″ long it is pinched to force out bushy lateral growth. This growth may be pinched several times if desired to develop a bushy top (or head). When the understock is well rooted in the pot and the top is of sufficient size the young tree roses (standards) are ready to sell.

ROSE HYBRIDIZATION

WILLIAM A. WARRINER
Jackson and Perkins
6767 Irvine Blvd
Santa Ana, California 92705

Rose hybridizing does not really fit into the usual concept of plant propagation; that is, making more plants of the same cultivar than what you start with. This kind of propagation is an important part of hybridization and will be touched on later, but the first requirement is to make or propagate plants quite different from what you start with.

Plant breeding is one of the really important aspects of agriculture having been one of the sciences contributing to the ever increasing production of food and fiber. There are many Ph.D's in universities and industry researching, teaching, and producing new products, plus all their support people. The size of individual crops is tremendous whether measured in acres, dollars, yield or any way you want to measure.

Rose breeding and rose growing are tiny parts of the agricultural industry, although one of the larger parts of the nursery industry. Rose breeding, along with other ornamental breeding departs, also, from a purely scientific nature to a mixture of science and art or aesthetics.

For the most part, rose breeding is supported by private business although a few universities and experiment stations in North America are doing a little and trying to get funded to do more. In Holland, there is government supported work on rose breeding, supposedly to develop an understanding of the genetics of hybrid roses, but Dutch breeders fear it will be government competition. This effort is separate from the Aalsmeer proofstation where new cultivars from all over are tested for performance as producers of cut flowers.

Europe, with a population comparable to that of North America, has, at least, 29 active commercial rose breeders, some small, but three; Kordes, Tantau and Meilland may be the largest in the world.

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In our country, there is only a handful of commercial breeders, under ten, plus a number of active amateur breeders. Another interesting comparison is in the consumption of rose plants and cut flowers. Great Britain, France and Germany each consume about as many plants as the United States. People of the European continent buy approximately ten times as many cut roses as Americans. The Aalsmeer flower auction moved over 800 million cut roses in 1979.

Roses have been desired by people for their beauty and scent for thousands of years. Travelers, whether they were traders or armies, often returned to their homelands with plants and seeds collected on their journeys. Roses were thus distributed throughout Europe and Asia and the art/science of rose breeding began.

Gardeners must have shown an increasing curiosity over the years when seeds of the various roses were planted and some did not come true It is generally thought that some natural cross-pollination had occurred giving rise to new hybrids.

Native European roses were large but flowered very little after spring. Some species of roses from China were prolific all-season bloomers but of less plant vigor and some not so winter-hardy.

Books and chapters of books have been written on the ancient roses and their progression to modern roses. To say the subject is confusing is a gross understatement. Records were not kept in ancient times and, in fact, gardeners did not really know where it came from when they saw a new rose. Up to a hundred years ago and, in many instances, even now, records were not kept even when crosses were known. Rose breeding got its start with the growing of seedlings from seeds collected in the gardens. There was no concern about what was crossed with what.

As examples of this, the parentages of two of the most famous roses of the Hybrid Tea group are not known or have ever been known. The cultivar, La France, given the distinction of being the first Hybrid Tea rose, was selected from a bed of seedlings growing from randomly picked hips at the nursery of the Guillot family near Lyon, France.

Another famous cultivar, Ophelia, was, reportedly, a mix delivered to Wm. Paul & Son Nursery in an order of the cultivar Antoine Rivoire 'Ophelia' became the progenitor of a large number of cultivars through mutations, seedlings and mutations of seedlings. Among its descendents are 'Columbia', 'Talisman', 'Joanna Hill', 'Briarcliff' and 'Better Times'.

Knowledge of the history of roses is interesting and helpful, but only as background information. One would be hard pressed

to conduct a rose hybridization program based on past history. Modern roses show little resemblance to ancient or species roses.

What, then, is rose hybridization?

The mechanics of crossing are quite simple, much simpler than some other species of ornamentals or food crops. Rose flowers are complete, with both sexes in each flower. Anthers are easily removed in preparation for hand pollination and to save for application to other flowers. The stigmas are large, easily examined without hand lenses and mostly are supported in plants in easily accessible positions.

Most rose pollinations are done in some kind of greenhouse although in mild climates reasonable success can be expected outside. Established plants, a little on the hungry side, make the most fecund and productive parents.

Two aspects of rose breeding are at the same time the most interesting and the most challenging. Rose breeders may argue the degree of difficulty or position of importance of these two. The first is selection of parents; the second, naturally, the selection of seedlings. In my opinion, the first is more complex and challenging. A third aspect of hybridization to be mentioned is the propagation of selected seedlings. The fourth aspect, the mechanics of pollination and seed handling, already touched on will be completed under the section on seedling selection.

Most of the firms active in rose hybridization are working in two or more areas of rose use, such as greenhouse, garden, miniatures, or landscape cultivars. In each area, there are needs for numerous classes and colors so that rose hybridization is a larger field than one would think.

But each cross made must have a reason to be made; there must be a definite objective. Once the objective is determined in the mind of the hybridizer, the next step, the tough one, is selection of parents.

For the most part, selecting parent cultivars is learned through trial and error. Obviously, one would select parents of his hoped for objective which showed characteristics approaching the objective. Also, obviously, the breeder is trying to develop a cultivar better or different than existing ones and must put together parents whose different types will be complementary and additive.

Many cultivars, excellent in themselves, are not particularly good as parents while others, not very good in their own right, are fine parents. Often an unnamed, undistributed cultivar will be found to transmit certain traits to its progeny that make it valuable as a parent. One such cultivar, named but not widely distributed, is Konigen der Rosen. Its stiff stems and heavy, well-

formed petals made one of its seedlings, Mercedes, one of the best roses in recent times.

Essentially, cultivars are tried as parents because of what *they look like, but are retained as parents because of what their* seedlings look like One European breeder believes that a population of seedlings from self pollinated flowers of a cultivar can give a clue to the value of that parent.

Little things can be important, also. In breeding for cut flower cultivars, thorniness is one consideration. It has been found that thorniness of the rachis is inherited independently from thorniness of stems. A thornless rachis is a valuable asset to a cut flower cultivar as well as a thornless stem. It's just a little thing, but to the person cutting roses, it can make a big difference.

The question is often asked "What do you look for in a new rose?" The answer primarily in two parts is novelty and performance, but this is too obvious. What is novelty and what is performance? We usually think of novelty in regard to the flower; *color, form, fragrance and performance as the way the plant* grows and manufactures the flower

There is so much difference between the requirements of greenhouse cultivars and garden cultivars that it is almost like two different crops. There is much latitude allowed in garden cultivars as to color, size, plant habit, etc., but the cut flower people are very demanding. The range of colors is small, and the type of flower is restricted, flower production is very important and thorns are bad news. Novelty is less important than performance. We have found, as have others, that one cannot evaluate garden roses in a greenhouse or greenhouse roses outside.

Major rose breeders will work with over 100 cultivars, usually closer to 200, to develop their program for any given year and these will be changed from year to year as the hybridizer learns more about them. Each hybridizer works a little differently, but essentially a program of crosses is laid out for the pollinating season (spring), the hips develop and are harvested in late summer

Seed treatment has been studied and studied over many years with little or no improvement. Some say stratification is essential, some say not. I have never been able to prove that it is or is not. In practice, we begin to collect hips in August and begin removing seeds in September. The seeds are placed in moist peat in plastic bags and stored in a refrigerator at approximately 4.5°C (40°F) until all are collected. Sowing begins when all seeds are ready, usually late October. It works out that some have been stratified six weeks and some maybe only a few days.

Leaching seeds in plain water for four or five days also seems to hasten germination.

Years ago, seeds were sown close together in flats, transplanted into pots when very small and shifted up to larger pots or, in California, lined out in the field. Evaluations were made as the plants grew larger or in the field, usually beginning in the spring after lining out.

Most breeders, today, plant seeds in benches in greenhouses spaced about one inch apart in rows five or six inches apart. They are never transplanted. As they bloom, the very bad ones are rogued out and the good ones are budded onto rootstocks in the field From a crop of 200,000 seeds, a hybridizer can expect a little over 100,000 seedlings and from this about 1,000 selections are made, each being budded to 10 or so stocks.

In the process of evaluation over a period of years, the best are increased and most of the original selections discarded. From pollination to sale is usually eight to ten years for garden cultivars and maybe a little less for cut flower cultivars.

Greenhouse cultivars can be propagated more rapidly by grafting and re-grafting in the greenhouse. There is much interest now and some work being done to propagate using tissue culture methods. The rate of increase is fairly fast and some differences in final plant habit have been observed. So far, the biggest difference is that plants seem to branch more profusely from the base.

New cultivars and certainly progress in improving roses come primarily from controlled pollination of carefully selected parents. Mutations (sports) have been very important throughout the years as sources of good, even outstanding new cultivars. Here are a few famous cultivars originating as mutations.

'New Dawn' — A hardy climber. This variety has the distinction of holding United States Plant Patent #1.

'Better Times' — Millions of these near red roses were grown in greenhouses during the '30's, '40's and '50's. It was a good producer but has been surpassed by red cultivars of much finer color.

The source of 'Better Times' was a popular pink cultivar named 'Briarcliff' which, itself, was a sport of 'Columbia'.

'Texas Centennial' — a sport of 'President Hoover', was very popular as a garden rose.

A pink shrub rose called 'The Fairy', discovered in 1932 was a sport of a white rose named 'Lady Godiva', itself a mutation. 'The Fairy' is now seeing a new popularity in Europe where far more roses are used in landscaping than in the United States.

A recent hybrid greenhouse orange cultivar from Kordes, named 'Mercedes', has proved to be one that mutates easily. It has given off several red sports, two of which, 'Gabriella' and 'Jaguar' are widely grown and a lighter version, 'Romeo', is fast becoming popular, and quite a few others.

HUNTINGTON BOTANICAL GARDENS — A SAMPLER

AUDREY TEASDALE

The Huntington
Library • Art Gallery • Botanical Gardens
San Marino, California

The Huntington is known for many things: the paintings of Blue Boy and Pinkie, the Gutenberg Bible, and a renowned Library of American and English literature used by scholars from around the world.

As plant people, are we aware of the plants the Huntington Botanical Garden has introduced to the U.S. and of the annual plant sale which attempts to make these introductions and other rarities available to the public? The remnants of the first commercial avocado orchard is still in existence at the Huntington. The Huntington is one of the West Coast quarantine center for imported bamboo. Within its 13 different gardens are collections of many genera of plants including the largest world-wide collection of mature cactus and succulent specimens grown outdoors.

In 1901 Henry E. Huntington, the founder, purchased what was then the San Marino Ranch. Huntington had by this time created and developed the clean and convenient electric streetcar system throughout Los Angeles. Huntington's goal pertaining to the garden was to determine "which of the world's plants would thrive in southern California." This brought plants from all over the world so that today we can enjoy mature selections of choice plants. Fortunately, Mr. Huntington set up a trust so the Library, Art Gallery, and Botanical Gardens are privately endowed and there is no admission charge to the public.

Let's take a visual tour through a few of the Gardens and talk about some of the interesting plants along the way.

The North Vista is our formal Italian Garden with a view of the San Gabriel Mountains as a background. This area contains collections of various camellia species. In between the 17th century statuary are azaleas and many choice trees. Our oldest *Camellia japonica*, 'Pink Perfection', was here when Mr. Huntington purchased the property almost 80 years ago.

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As we enter the Shakespeare Garden we notice the masses of color of seasonal annuals. The Garden is a modern design including plants that were widely grown during Shakespeare's time (1564-1616). The small trees are *Citrus aurantium* 'Chinotto'. Beneath the 'Chinotto' is a small knot garden which is an elaborate pattern of clipped herbs which give the effect of being intertwined — *Lavandula, Santolina, Teucrium.*

Leaving this area, we come upon our *Magnolia delavayi* — the largest leaved evergreen magnolia Native to China, it was discovered by the French missionary, Delavay Our specimen is 32 years old. In early spring it's covered with large buds which open into 7″ creamy white fragrant flowers.

We are now in the Rose Garden. The Rose History walk follows the perimeter from the oldest rose to the modern hybrid teas in the Central Rose Garden.

A detour into our Pavilion area lets us gaze upon *Prunus serrulata* 'Pink Cloud'. Each spring this vigorous selection produces a mass of large showy pink flowers

As we continue our walk, we spot a plant growing on the arbor above. The plant resembles wisteria, but has very glossy leaves, is flowering in September, and instead of long, drooping panicles of purple flowers it displays small, sweetly scented dark maroon flowers. This is *Millettia reticulata* from China — our evergreen wisteria which, botanically speaking, is in the same family as wisteria (Leguminosae) but is generically distinct.

Now we enter the Japanese Garden (which, more properly, should be called an Oriental Garden); it was designed in 1912 The gong is from Japan and the structure is built in the traditional Japanese style without nails — only wooden pegs. The ram is not made of *Chamaecyparis obtusa,* Hinoki cypress, as in Japan, but is an agave flower stalk from our Desert Garden

The Chinese Moon Bridge is probably one of our most photographed structures and most people when seeing a picture of it recognize it to be at the Huntington.

As we continue past the pond and up the slope we encounter a typical house built in the 1800's of a wealthy countryside Japanese family. This house, the bridges, and some lanterns were acquired in 1912 from a commercial tea garden in Pasadena. During visiting hours, both the amado (rain doors) and the shoji (inner doors covered in rice paper) are opened displaying the inside of the house.

Also in the Japanese Garden is the Zen Garden. This is a dry garden of individual interpretation. Originating from the Buddhist religion, it is a spot for peaceful and thoughtful contemplation.

Our Australian Garden contains ten acres of plants from Australia and New Zealand. We have approximately 100 species of eucalyptus — both trees and mallees. *Eucalyptus macrocarpa* is unique in producing its flowers singly and has one of the largest fruit of any eucalyptus.

The Subtropical Hill is one of my favorites. It is located on a southern slope and is the warmest spot in the garden, giving us the potential to grow plants that may be borderline tender here. Not only have we plants from all over the world, but even some recently introduced to Southern California, such as the *Citrus limon* 'Sun Gold' which is not even out in the trade but has much promise. The tree is variegated with over 20 shades of yellow and green with the flesh of the fruit showing variegation also. Plants from the Mediterranean can also be found here, such as a 70 year old *Pinus pinea*, Italian Stone Pine, which silhouettes the sky with its huge umbrella crown. As we continue on these winding trails, we find the Mexican creeper, *Antigonon leptophus* — a climber up to 40 feet — that was collected in Mexico during a Huntington expedition. Making a mass of color from June to November is a good ground cover one foot in height — the *Zinna maritima* or Acapulco Daisy It was introduced to this country from Mexico by the Huntington. Our annual Plant Sale provides funds for annual expeditions that make these introductions possible

Leaving the Subtropical Hill, we can't miss the Ombu tree — approximately 60 years old, *Phytolacca dioica*, from South America. This plant, with its swollen trunk, is referred to as "The Ships on the Pampas" in South America. In the hot, flat grasslands the trees look like huge ships floating upon the sea of grass.

The Lily Ponds were built in 1904. To have the tropical water lilies and giant *Victoria amazonica* (Syn.: *V. regia*) in flower till mid-January, over 1,000 feet of 2″ galvanized pipe was installed along the walls of the pond and was connected to a hot water boiler. It actually worked!

Podocarpus reichei is another introduction into this country by a Huntington expedition to Mexico. It has a graceful habit with leaves much longer than *P. macrophyllus* and, in our garden, has taken temperatures to −4.5°C (24°F).

Our Jungle and Cascade was completed in 1980 and contains plants that typify a jungle — many of them epiphytes such as our introduction, *Platycerium ridleyi*, Staghorn Fern, received in 1973 as spores from Malaysia. However, this plant may prove to be too tender for our garden. Another introduction in this area is a plant now found widely in the trade — *Schefflera arboricola*, which was introduced by the Huntington from seed received in 1965 from Taiwan. *Dombeya cacuminum* is a dense columnar

tree, growing 30′ tall in 12 years. Its flowers are a vibrant red and it has the attributes of flowering later than most *Dombeya* and its flowers do not hang on the tree as do those of *D.* × *cayeuxii* or *D. wallichii.*

Our Palm Garden is 4 acres. The *Jubaea chilensis,* Chilean wine palm was apparently being cut down rapidly in Chile. Within these massive trunks is a sap yielding up to 90 gallons of commercial palm honey which can be fermented to make a wine. Fortunately this practice has stopped.

The Desert Garden at the Huntington brings thousands of people annually to visit. This Garden and the Japanese Garden are undoubtedly the public's two favorites. This is the largest collection in the world of mature cacti and succulent specimens grown outdoors. During the winter months the Garden is a mass of red from the flowering South African aloes. The Mammillaria Bed was established in 1930 and is made up of Arizona volcanic rock, it is approximately 1/5 mile long. The Golden Barrel Cactus, *Echinocactus grusonii,* is well represented with large and mature specimens in the Garden.

Along the main road are sun and winter hardy succulents tested for their use as groundcovers. New future projects in this Garden include a Baja California bed and a glasshouse for plants unable to be grown out of doors.

I'd like to welcome all of you to visit the Huntington Botanical Gardens in San Marino, California. We are closed the entire month of October, but are open 1:00 to 4:30 Tuesday through Sunday the rest of the year.

AVOCADO NURSERY PRODUCTION

DIETER W LODDER

La Verne Nursery
La Verne, California 91750

The propagation of avocado trees has been discussed before this group a number of times. I presented the details of avocado production, as practiced at La Verne Nursery, at the Western Region Meeting in San Diego in 1974 (2), and a very detailed account on the same subject was given by W.H. Brokaw in 1977 (1).

I should point out that the avocado trees which have been planted in California during the last 20 or 30 years were produced by specialized growers who produced several hundred thousand trees annually, while only a relatively small amount of

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I should point out that the avocado trees which have been planted in California during the last 20 or 30 years were produced by specialized growers who produced several hundred thousand trees annually, while only a relatively small amount of

avocado trees were used for the home garden. At La Verne Nursery, we have been propagating avocado trees since 1972, primarily for the retail trade.

During the last few years avocado tree producers in California had to reduce their volume due to a decline in demand for avocado trees. The reason for this is that most of the available agricultural areas in the relatively frost free coastal zones of Southern California have been planted to subtropical fruit orchards of many kinds including avocados. In addition, more and more prime grove land was converted into residential housing tracts.

Yet, there are still areas where avocado groves are being planted but their lng term future is in jeopardy because of fast rising land and water prices, restrictions on the use of water, and the ever-present threat of infection of a grove with the root rot fungus, *Phytophthora cinnamomi*. *Phytophthora cinnamomi* will affect many species of plants, however, it is most devastating to the avocado industry in that it destroys year after year from 10% to 15% of all avocado groves in California.

Deep fumigation of the soil with heavy doses of methyl bromide or Vapam have, at best, provided marginal results. Surface applications of Terrazole only result in slowing the spread of the fungus. A new fungicide, Ridomil, produced by Ciba-Geigy looks very promising and good results are being achieved with its application in foreign countries, where it is registered for use in bearing avocado orchards. According to a recent report by a San Diego County farm advisor, Ridomil is being applied to *Phytophthora*-infested groves in South Africa at the rate of 2½ grams per square meter with a 5% material three times per year. The results there are fascinating in that trees which were at a point of 75% decline, were brought back to normal health and productivity with the use of this chemical. Fortunately, in the United States, Ridomil is being tested and registration for use on non-bearing trees will be available in the near future.

A chemical named Aliette is currently under laboratory testing at the University of California at Riverside. It is hoped that this material, when applied to the foliage, will render the trees resistant to pathogens.

In the area of research for root rot resistant understock cultivars much work has been done which resulted in the development of at least two, which have been named 'Duke #47' and 'G-6'. Their level of resistance to root rot is classified upward of 80% when planted into root rot infested soil. Orchard trees grafted on these resistant understocks are becoming more readily available as propagation techniques for these vegetatively grown understock cultivars have now been developed. Trees grown on

the root rot resistant clonal understock are growing well, and they are expected to be as vigorous and productive in the orchard as trees grafted on seedlings

Most avocado trees planted in the United States and other suitable locations throughout the world are grafted or budded on seedling-grown understock. In California, the most popular cultivars are 'Topa-Topa' and 'Lula'. Both produce a fairly large seed which generally stays in good condition during the early life of the plant in the nursery, providing it with nutrients in addition to chemical fertilizers provided by the grower. Another important factor is their compatibility with scions of all commercial orchard cultivars.

Since the development of a rather efficient method of propagating avocado trees in the greenhouse, most growers have abandoned more conventional methods. Following is a brief description of this method which is being used at La Verne Nursery:

Here in southern California, seeds of the avocado cultivar, 'Topa-Topa' are available in October and November while 'Lula' seeds are brought in from Florida at about the same time. The seeds are cleaned and placed into a coarse-meshed container which allows water to flow freely among the seeds (onion sacks are quite useful) Seeds are submerged in water at a temperature of 49°C (120°F) for 30 minutes, followed by cooling off in cold water. From the cold water the seeds are transfered to a fungicidal dip or to a mild solution of sodium hypochloride. The hot water treatment is to remove *Phytophthora cinnamomi* spores which may adhere to the seeds, and the fungicidal dip is necessary as a safeguard against hardier fungus diseases, such as *Rhizoctonia*, which require 145°F or higher temperatures for elimination, a temperature not tolerated by avocado seeds. Seed coats which adhere firmly to the seeds are removed at this time by cutting a slice about ⅛″ thick from the seed at the bottom and the top. This allows for unobstructed root and top growth. The seeds are then planted into prefilled seedling bags, 5.3×5.3×23 cm (2½″×2½″×9″) in size, solidly placed on sterilized greenhouse benches. The growing medium is a blend of peat moss and perlite which is also used as top dressing for the seeds.

Less than two months after the seeds are planted the young seedlings are ready for grafting. A short cleft graft is used. The grafts are covered with a single sheet of newspaper until leaf petioles begin to fall off and buds on the scion begin to swell. As soon as new growth and foliage develops the grafts are moved out of doors into full sunlight and are planted about three weeks later into 5 gallon containers filled with sterilized soil. The ground below the containers is disinfected between crops with Mylone, and immediately before planting a thin layer of Copper

Bordeaux (12½% copper) is applied to the surface. In addition, roadways into avocado growing areas are treated heavily with Bordeaux and the use of step-thru containers containing Bordeaux for use by foot traffic is strictly enforced.

As mentioned earlier, most of our trees are grown for the retail trade and eventually homeowner's use. In contrast to the flexible poly sleeves used as containers by growers who produced trees for orchards, our trees are in metal containers in which they can be easily maintained by the retail nursery. Our containers are designed especially for avocado and citrus trees. They are 35.5 cm (14 in) high and 20.3 cm (2 in) in diameter with a number of holes in the bottom plate, which allows for water exchange with the soil below.

Under proper growing conditions a 5 gallon avocado tree should be saleable 10 months after the seed is planted. While an avocado tree grown for orchard use is acceptable for planting at a size of two feet above the graft, the retail trade desires a tree about 3 to 4 feet in height, well branched, healthy and mature in appearance, with a stake that will support it until the tree is established in its permanent site.

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2 Lodder, D W 1974 Grafting as a business. *Proc Inter Plant Prop Soc.* 24:36-39

MODERATOR KATHY VAN VEEN: Do we have some questions now for our speakers?

VOICE: Dieter, you mentioned that you put newspaper over avocado grafts just after you are finished grafting; that is a new thing to me. You just lay it right on top of the graft, physically in contact?

DIETER LODDER: This is true. The idea is to take the paper off just as soon as the leave and petioles fall off the scionwood and then, as I said, the new growth grows right into full sunlight, requiring little or no hardening off under shade once the plant is moved outdoors

VOICE: It is in a greenhouse that you are doing this?

DIETER LODDER: Yes

VOICE: What is the sunlight in the greenhouse? What is the intensity?

DIETER LODDER: I haven't measured it. I should be able to tell you what it is. The grafting is done during the winter months. Often we have overcast weather — we have rain. Then we have

bright sunlight Usually with the initial cover up of newspaper, which is removed, the plants go right into practically full sunlight in the greenhouse It requires a lot of cooling sometimes but we open up the greenhouse doors and that helps.

AUDREY TEASDALE: I would like to address a question to William Brokaw. What are the kiwi cultivars that you grow in southern California and which are easier to propagate by cuttings?

WILLIAM BROKAW: I don't know which are easier to root; they are all hard for us to root. I think that 'Hayward' may be easier than 'Chico Hayward'. I might make two suggestions with cultivars in southern California. One of them is if you are choosing between 'Chico Hayward' and 'Hayward', that you choose 'Hayward'. The second is that if you don't have enough chilling for 'Hayward', there are a couple of other cultivars which you might use. One is 'Bruno', which is from Australia. The fruit has an unfortunate shape, however, and some people do not like the flavor as much. It looks like a fat sausage; it is long and narrow. Another cultivar is one that was discovered as a seedling by Fred Vincent from Yorba Linda, California. This is a warm winter region and an area which had gone out with avocado root rot. This cultivar is called 'Vincent'; it fruits very well for him although the fruit is somewhat smaller than 'Hayward'. In our nursery at Saticoy, California, as well, it has fruited very well whereas all of our 'Haywards' or 'Chico Haywards' that have fruited have been from chilled budwood from the California Central Valley which has relatively cold winters.

SOLAR EFFICIENT GREENHOUSES

WILLIAM L. NELSON

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4301 Lynnwood Drive
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With the current interest in energy conservation, the efficiency of greenhouses has come under close scrutiny. The use of double walls, ground insulation, tight doors and vents is now common practice. Several new ideas are being put to use and it seems certain that energy costs can be reduced even more. I'd like to review four areas that show great promise:

Placement and Design. A complete turnabout in thinking has occurred in the orientation and construction of greenhouses. It has been found that for maximum solar energy entry, the single-

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Placement and Design. A complete turnabout in thinking has occurred in the orientation and construction of greenhouses. It has been found that for maximum solar energy entry, the single-

span building should be positioned in an east-west direction. The north wall should be opaque, well-insulated and at an angle of about 60°. The south wall or roof performs best if built at an angle of 35° to 45° (1).

Heat Delivery. Space heating may soon be replaced by bench or floor heating. Don Dillon's Four Winds Nursery in Fremont, California, is one of many that have had success with the use of hot water circulated inside the bench. Whitcomb reports improved plant growth and fewer disease problems with this system, and the energy savings are substantial (4).

Heat Storage. Great strides are being made in the storage, for later use, of the heat that penetrates a greenhouse. When this is done effectively, added heating is unnecessary. If the storage medium is thought of as a sponge that pulls in and holds excess heat, it is easy to understand how this approach will also reduce the need for cooling and shading.

Air is not the best substance for heat storage. When we realize that the air inside a well-insulated and weather-stripped house is completely changed in just two hours, the limitations of air for this purpose become obvious. Soil, stone, and concrete are nearly equal in heat-storing capacity. Water retains heat five times better than these materials and has, therefore, been the first choice.

Salt hexahydrate is now coming into use and has exciting possibilities. This material changes from a solid to a liquid form at 27°C (81°F) and stores *eight* times more heat than water.

This surplus heat can be stored anywhere that does not block the solar radiation — even outside the greenhouse. I believe that the best location is directly under the benches. The natural rising of released heat passes it through the planting media in an ideal manner.

Plant Environment. A revolutionary method of propagation with the use of "ventilated high humidity" has been described by Milbocker (2,3). It sounded very promising and, because it made such good sense, I purchased the necessary equipment from the Agritech Company. In use since June, 1980, (3 months), the results have been noteworthy. Previously I used mist and had a constant battle with over-watering, drying-out and fungus problems. I am now able to take much larger cutting material and have been more successful with difficult-to-root plants. This system also meshes well with solar energy storage. The temperature of the planting medium remains slightly higher than the surrounding air and the circulating fan distributes the warmer air evenly, to assist in heat storage during daylight hours. Relative humidity of 90% to 95% is maintained at all times allowing plants to tolerate a higher temperature level. This, in turn, facili-

tates the storage of more radiant energy and reduces the need for cooling and shading.

As we learn to apply these improvements in greenhouse technology, energy conservation will be automatic. It seems that we can also expect fewer disease problems and a healthier plant as an end product.

LITERATURE CITED

1 McCullagh, James C 1978 *The Solar Greenhouse Book*, Rodale Press, Inc

2 Milbocker, Daniel C 1977 Propagation in a humid chamber *Proc Inter Plant Prop Soc* 28 455-561

3 _____ High humidity propagation promotes healthy, vigorous plant growth *American Nurseryman* May 1 15

4 Whitcomb, Carl E 1977 Self-contained solar greenhouse Oklahoma State University, Stillwater, Oklahoma

RADIANT HEATING FOR PROPAGATION AND ENERGY CONSERVATION

CHARLES M. HOAGLAND

Infrared Systems
Mount Vernon, Washington 98273

I want to introduce a concept of heating that is new to the greenhouse industry, but is as old as the sun. The system is a gas fired, low intensity, infrared radiant system Infrared is proving to be an ideal method of heating greenhouse crops from propagation to finish while saving substantially on fuel consumption. The name of the system is CO-RAY-VAC and it is manufactured by Roberts-Gordon Appliance Corporation.

Infrared energy is as old as the sun and its principles have been applied for many years in heating. The cave man used it when he heated the rocks around his campfire. The sun itself is the source of infrared energy which heats the earth's surface. Infrared radiation is energy in the form of electromagnetic waves and has some similar properties to visible light waves. Light, radio waves, x-rays are all electromagnetic waves with different wave lengths and physical properties. Infrared energy travels in a straight line until it strikes and is absorbed by the object to be heated. The energy is then converted into heat that warms that object. In other words, heat is transmitted from one object to another without heating the air between the objects. The radiant heat does not directly warm the air, but the object receiving the radiation is warmed and acts as a heat exchanger to warm the air. The objects warmed by radiation then warm the air due to

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the principles of conduction and convection. During the heating cycle the air within the greenhouse will be warmed to almost the level of the soil and plant temperature. The air temperature will not exceed the temperature of the objects in the greenhouse heated by infrared radiation.

Conventional heating systems encounter a very difficult problem in that they are basically air heaters. That is, they heat the air and deliver heated air to a desired area. There are three physical principles working against each other in such a system:

1. Warm air rises.
2. In the presence of rapidly moving air, plants and people are cooled.
3. Air movement inside the greenhouse contributes to heat loss to the outside covering.

These factors are in conflict with each other when economics are considered. In order to move the lighter weight heated air down to the level occupied by the plants, we must force the hot air down with fans or turbulators consuming considerable electrical energy. The result is that by moving air we are cooling the plants in order to warm them. The same thing occurs with people. Human comfort at 19.5°C (67°F) is matched with about 15.5°C (60°F) using low intensity radiant heat. When using infrared as a means of heat transfer, we are able to eliminate this basic problem. Infrared energy travels independently of air. Since moving air is not required in delivering infrared heat, we are able to heat the plants by directing the infrared rays to the area we want. By using draftless heating we have developed a new and economical means of heating greenhouses. Savings have exceeded 60% heating with CO-RAY-VAC when compared with systems heating the air.

Hot water or steam pipes placed under benches are hotter than the air, and convection currents around the hot pipes move heated air up to the top of the greenhouse through the benches to be lost through the roof. Placing the pipes in the soil on the bench and insulating below may improve efficiency but still would not match the advantages in savings generated by the radiant CO-RAY-VAC system. Savings have exceed 50% heating with CO-RAY-VAC when compared with steam systems.

Four years ago, I was maintenance supervisor for Skagit Gardens, a wholesome greenhouse located in Washington State. Primarily they produce bedding plants, poinsettias, and flowering perennials. I worked three years there and during that time fuel costs dictated that we consider some means of fuel conservation. Double poly was not acceptable due to the low light already available during winter months. Washington is not known for lots of sunny days — some winter months we don't even see the sun.

Also, experience with unit heaters in dealing with cold and hot spots, frequency of repair, and cleaning and annual replacement of poly tubes, led to considering alternate ways of heating. The local gas company recommended we look into radiant heat. After studying the infrared system of heating it seemed to be a sound concept and the application in the greenhouse appeared to be practical. After nearly five years of use and comparisons with other heating systems, it is well received and endorsed as a new concept in greenhouse heating and fuel economy. Our test data was printed in the September, 1978 issue of the "Ohio Florists' Bulletin". CO-RAY-VAC saved us over 60%.

The infrared system is hung as high as possible in the greenhouse out of the way of plants and equipment. The gas is fired inside a four inch pipe and the heat warms the pipe to between 500°F and 900°F. The radiant pipe is covered with a lightweight polished aluminum reflector which directs the infrared rays towards the plants and floor of the greenhouse. The heaters are fired in series with one about every 20 to 40 feet depending on burner size and requirements. A vacuum pump pulls the gases down the tube and exhausts them outside the greenhouse. The pipe section twenty to thirty feet past the last burner is referred to as the tailpipe. It is at the cooling end of the heating system where the last of the heat from combustion is released. To meet the heating requirement for Northwest Washington in houses 21′×158′, four 60,000 BTU units were used, providing a total of 240,000 BTU's per house. These proved to be more effective than the houses equipped with two 200,000 BTU unit heaters directed into fan jets with convection tubes at each end of the house for a total of 400,000 BTU's.

Some of the important advantages of infrared as applied to greenhouse heating are as follows:

1. The compact linear design of the system readily adapts itself to greenhouse application. It is lightweight, about 3½ pounds per linear foot, and casts only a narrow shadow the length of the house.
2 Clean, safe, and comfortable growing and working conditions are provided. Several built-in fail-safe features reduce the danger of leaking gas or fumes into the greenhouse and the chances of fire or explosion. Personnel feel very comfortable working under infrared heating.
3. High efficiency in converting fuel to radiant energy provide substantial savings in fuel costs. The infrared waves are directed downward so the heat radiates to the lowest point in the greenhouse which is either the plant, the walks, or the benches.
4. Infrared radiant energy is converted to heat when it strikes

an object and is absorbed by the object to be heated. The exhaust gases leave the system at 100° to 125°F, indicating that nearly all the heat has been taken out. Because objects are heated (not air), it is unnecessary to move air to deliver the heat. By eliminating the problem of heated air rising to the peak of the greenhouse, the heat difference between the inside and the outside is much less, which greatly reduces heat loss to the outside.

5. Incremental units allow for zone control of heating. Systems can be designed so that various areas can be heated independently of other areas.
6. Uniform heat distribution allows for more uniformity and quality control of the products. The reflectors direct the heat in a rectangular pattern corresponding to the shape of the greenhouse. Cold ends and sides are no longer a problem as a well designed system gives uniform heat distribution.
7. The CO-RAY-VAC infrared system is not affected by negative pressure in the greenhouse. Exhaust fans, drafts or high winds will not reduce the heating effectiveness because the system operates at a negative pressure greater than experienced from outside forces.
8. The infrared rays can be directed at the objects to be heated. Only the plants, benches and walks receive the energy from the infrared rays. The soil and walks serve as a heat sink that slowly release heat between heating cycles. The plant tissue is warmed even though the air is not heated directly. The warm soil, walks and plant tissue act as heat exchangers and warm the adjacent air, but productive growing conditions are achieved at air temperatures about 7°F lower than that required by a hot air system.

To understand the principle of infrared heating one must realize that this is a totally different concept than conventional hot air systems. The basic difference is that objects are heated directly with the radiant energy. The heated objects then warm the air touching them. (With heated air systems, the warmed air heats the objects.) With infrared the objects are warmer, the air cooler, thus reducing condensation or high humidity on or near the plant. This condition is desirable to aid in control of plant diseases. To move air with circulating fans in an infrared system would defeat the major advantage of the system. Because of the 900°F heat generated by the burner it is necessary to use care in placing plants near the reflector or hanging the system directly above flammable objects. Some injury to temperature-sensitive plants has been experienced where hanging plants were less than five feet from the heat source. Many heat tolerant plants have shown no injury when growing within three or four feet

from the radiant pipes.

In order to establish an accurate record of the amount of fuel burned, a separate meter was installed to measure the amount of gas burned by the infrared system. After one full year the data provided by the local gas company showed an average of 62% reduction in fuel consumption for the CO-RAY-VAC infrared system compared to unit heaters and convection tubes. At this writing, the savings has consistently been in the area of 60% after over four years of use. Additional systems have been installed to now heat 70,000 square feet of glass greenhouse space. A new area of 60,000 square feet of glass to be heated with CO-RAY-VAC is currently under construction

In addition to reduced gas consumption, it was discovered that the electrical energy required to operate the heating system was only 10% of that required to operate unit heaters and convection tube fans.

In our installation the energy savings were enough to pay the entire cost of the equipment and installation in two years. The cost of energy now has increased to the point where in 1980 the savings will be equal to the original cost and each succeeding year the amount of dollars saved will be greater. We estimate that over a ten year period, with expected energy cost increases, we will save an amount in excess of ten times the original cost.

Infrared radiant heating has now been used successfully on a wide variety of greenhouse crops. Plants grown on the floor, raised benches, hanging baskets, or even densely populated combinations of the above have all responded favorably to this even, gentle means of heating. At this time, no crops have shown adverse effects in a properly installed infrared system. One should be careful to follow factory recommendations to insure the best results. Comparing the trade-offs one must accept with other means of energy conservation now on the market, infrared offers so many advantages that it promises to be the heating system of the future.

X-RAY DETERMINATION OF HORTICULTURAL SEED QUALITY

C. JAY ALLISON

Weyerhaeuser Company
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Abstract: X-radiography is a quick and inexpensive means of assessing soundness of the internal structure of seeds. an indirect indication of seed viabil-

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ity Testing of seed quality before sowing can ameliorate problems of low yield or overcrowding in the propagation of perennial ornamental plants

INTRODUCTION

Vegetative propagation techniques are the most widely used for production of perennial ornamental plants. They are the preferred and sometimes necessary routes to reliably preserve the desirable genetic characteristics of the mother plant Of various vegetative techniques, rooting of cuttings is most popular for woody cultivars. One advantage of sticking cuttings into rooting flats is that the number and distribution of plants can be accurately controlled. Overcrowding and excessive competition are avoided. Another is that propagation material can be collected without depending on seed production.

Still hundreds of kinds of perennial ornamental plants are propagated from seed; either for marketable plants or for rootstocks for grafting. Production from seed is often preferred for those kinds that can be vegetatively reproduced only with extreme difficulty, or under extraordinary conditions. A major advantage is that the cost, in time and labor, of preparing seedling flats is substantially lower than for preparing flats of cuttings.

In spite of the productivity advantage in using seed, there are some problems specific to propagation from seed. It is not rare for only a few seeds to germinate from several hundred seeded into a flat. Such events are wasteful of labor and time and of space in the propagating facility. In extreme cases, new seed must be obtained and the crop resown if quotas are to be met. Even then, a substantial amount of time may have already been lost waiting for germination.

If the new seed is of high germinability and good vigor, misfortune may strike again in the form of overly dense seedlings. Root entanglement is more severe and separating roots slows transplanting and increases injury to seedling roots. Seedlings tend to be leggy and unable to support themselves after transplanting. Late-germinating seedlings are often repressed. This results in seedlings having a large range of sizes. Control of disease is more difficult among crowded seedlings. Thinning back to a desirable density is usually not done because of added labor costs.

There is then, a problem of predicting seedling yield from a given seed lot. Many factors can influence seedling yield. Pretreatment of seed, time of sowing, level of sanitation, and environmental factors can certainly affect rate and extent of germination. But a frequent cause of poor seedling yield is simply poor seed quality. Factors that contribute to low seed quality include: absence of endosperm or embryo, embryo immaturity, genetic

defects, insect infestation, seed diseases, lack of freshness, and poor storage conditions.

SEED TESTING

Germination Test. The reliability of seedling propagation can be enhanced by testing seed quality before sowing. Given some measure of seed variability, the propagator is in a position to adjust his sowing rate to result in the desired yield and density.

The most reliable test of seed viability is the germination test. Replicate samples of the seed lot are subjected to controlled conditions for a specific period of time after which the percent of germinated seed is determined. This type of test is particularly well-suited to agricultural crop seed which generally requires little or no pretreatment and germinates within a few days. The seeds of many perennial plants, however, often require weeks or months of pre-conditioning to enhance germination. Even then it may take weeks more before germination is complete. Unless the seed stores well, the lot from which the samples were drawn may significantly decline in vigor while the test is going on. This need for time and for special equipment make the conventional germination test unattractive for many ornamentals. Furthermore, the test is destructive in that the sample is consumed in testing. The 200 to 500 seeds needed for a reliable test can be a substantial portion of some ornamental seed lots.

Cut Test. There are a number of so-called quick tests that are useful in determining seed quality. The simplest of these is the cut test. Seeds are cut open and the interior examined. Those that are firm, full, and of healthy color are judged to be viable. This test can also be used to check ungerminated seed at the end of germination tests or in the seedling flats. With practice, one can learn to detect abnormalities in otherwise healthy looking seed. These might include immaturity, malformation, or inversion of the embryo.

Tetrazolium Staining. Among several biochemical staining techniques, the tetrazolium chloride, or TZ test, is the most widely used. In this test, seed is soaked in water for one or two days. The seed coats are cut or pierced to permit penetration of the test solution. A 1% aqueous solution of 2,3,5 triphenyltetrazolium chloride is the reagent. Specimen seeds are immersed in the solution and kept in the dark for 24 hours at room temperature. After rinsing, the seeds are cut lengthwise and red-staining of the tissue is evidence of viability. Variability in stain intensity sometimes makes interpretation difficult. Like the cut test, the TZ test is a destructive test and requires time-consuming handling of each seed.

Hydrogen peroxide stimulation of the germination test and culturing of excised embryos are other quick tests beyond the scope of this discussion. These, and the X-ray test to follow, are detailed in the bibliographic references.

X-ray Testing. Perhaps the most rapid of the various quick tests for seed soundness is the X-ray examination of internal seed structure. With soft X-ray, a large sample of seed can be examined. The production of an X-radiograph takes only a few minutes and the test is best performed on seed dried to normal conditions.

Another advantage is that the low radiation dose does not damage the seed. Correlative tests, such as germination or tetrazolium tests, can be performed on the same seed sample, or on selected individual seeds.

A major drawback to the X-ray test is that, like other quick tests, it does not provide a direct measure of seed viability. It does provide, for those seed for which it is suitable, an estimate of soundness or completeness of the material within the seed coat Absence of endosperm; absence, immaturity or malformation of the embryo; cracked or broken seeds; insect larvae; and shrinkage of the interior (an indication of "old" seed) are evident in the radiographs.

The equipment used for performing X-ray examination is available "off-the-shelf". The X-ray unit in our laboratory is a Hewlett-Packard "Faxitron" Model 43804N. The other major piece of equipment is a Kodak Ektamatic Model 214-K Processor for the instant paper radiographs. Sample holders, film holders, chemicals, photographic paper, radiation exposure badges, and a dark room round out the equipment and materials needed. The cost of the equipment and alternatives to direct purchase of X-ray equipment will be discussed below.

While operators must be trained in the safe use of X-ray equipment, the process for radiographic testing is quite simple. A representative sample is taken from the seed lot. In the simplest form, a known number of seeds can be distributed directly on the film holder. But to maintain individual seed identity and to simplify counting, the use of a compartmented sample holder is preferred. A Plexiglass plate, 5 mm thick, drilled with 100-15 mm diameter holes will accommodate all but very large seed. A 0.1 mm thick Mylar sheet is glued to the underside to hold the seed without significant attenuation of the X-ray beam. One seed is placed in each cavity and the sample holder is placed on the film holder which is then placed in the X-ray cabinet. The seed is exposed for a predetermined time at a selected X-ray tube potential. Exposure times are generally from ½ to 3 minutes at 15 to 20 kilovolts tube potential.

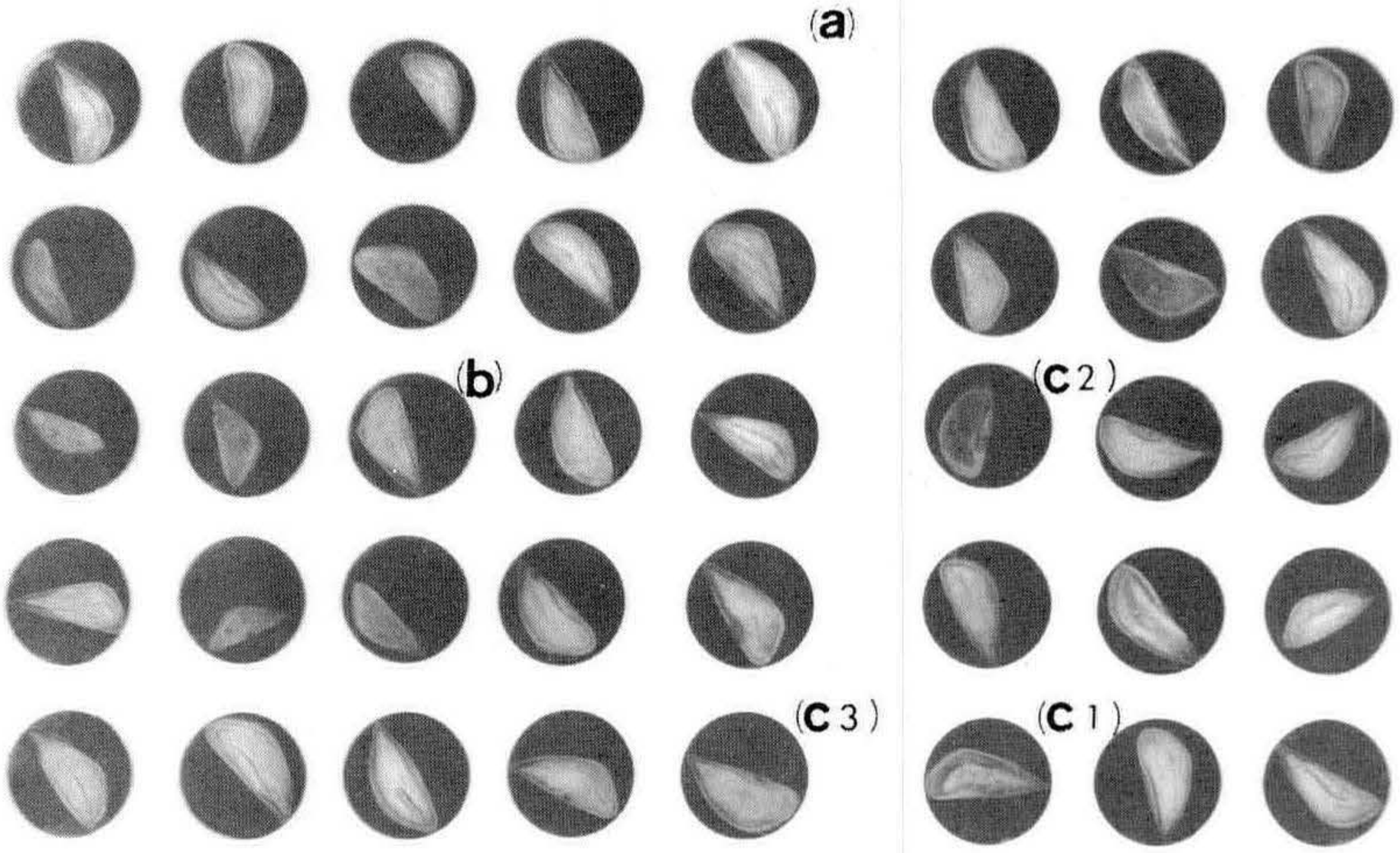

Figure 1. A portion of a radiograph of *Cedrus deodara* with examples of: (a) sound seed, (b) seed with questionable structure, and non-viable seed with shrunken endosperm (c-1), empty seed coat (c-2), and missing embryo (c-3).

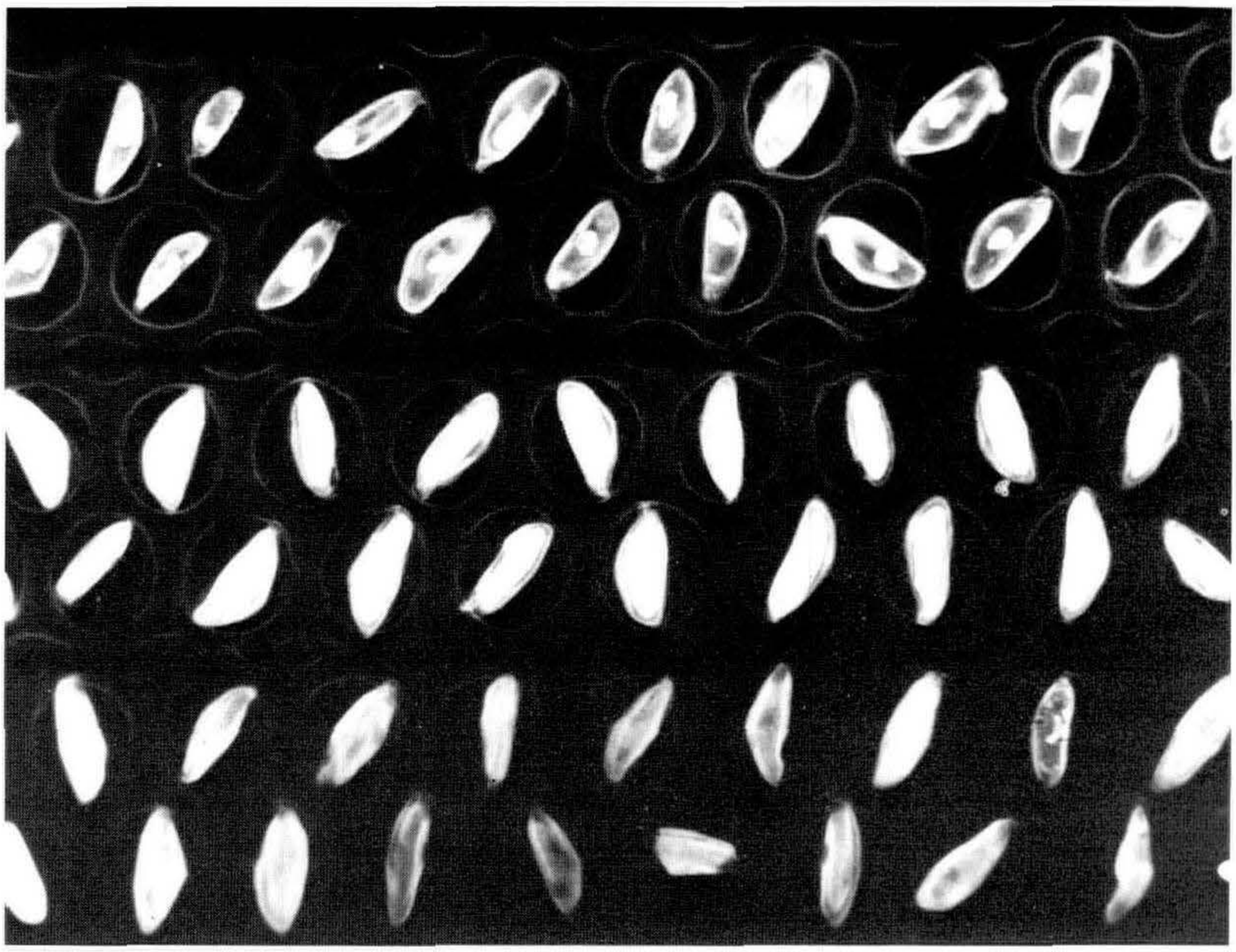

Figure 2. X-radiograph of *Abies procera* seed. Seed has been segregated to illustrate empty seed (top two rows), normally filled seed with distinct embryos (center two rows), and seed infested with chalcid fly larvae (bottom rows).

The exposed paper is removed from the holder under a photographic safelight and passed through the instant processor. The radiograph can be taken immediately into room light and a count made of the sound seed in the sample The radiograph can be dried and data recorded directly on the radiograph as a permanent record.

Seeds of the family *Pinaceae* are well suited to X-ray analysis. A radiograph of the seed of *Cedrus deodara*, (Figure 1), shows examples of (a) well-filled seeds with distinct embryos, (b) questionable seeds with indistinct or distorted embryos or space between the endosperm and seed coat and (c) obviously nonviable seed with empty seed coat, shrivelled contents, and missing embryos.

Abies procera, an important forest species of the Pacific Northwest, presents a clear image of the embryo in sound seed (Figure 2). Empty seed is easily identified and chalcid larvae infestation is distinct. For clarity, these have been segregated.

Insect damage has also been observed to the seed of species of broader horticultural interest. In seed lots of *Phoenix reclinata* and *Phoenix canariensis* seed-weevil larvae were found in nearly every seed. These seeds appeared normal under ordinary light except for tiny holes along the cleft of the seed.

Embryo distortion is frequent in *Strelitzia nicolai* (Figure 3). It is not known if this characteristic affects viability Using the radiograph, individual seed with distorted embryos could be selected from the seed holder and subjected to tetrazolium or germination tests. This ability to perform confirmatory tests on the same seed sample exemplifies the research value of X-ray testing.

Sometimes the distinction between sound and poor seed is a matter of degree, making interpretation of the radiograph difficult. Sound seed of *Acacia latifolia* results in a strong image but shows little or no detail of the internal structure. The endosperm of obviously dead seed is shrivelled or deeply pitted. But all degrees exist between these extremes and "lethal" level is uncertain.

Some seeds have characteristics that preclude making estimates of seed soundness by X-radiographs Since the X-ray equipment available to seed analysts cannot magnify the image, seeds with dimensions less than about two millimeters are too small to produce meaningful detail The pericarp or seed covering of some seed is so dense or convoluted that the details of interior structure are obscured as illustrated in the radiograph of *Harpephyllum caffrum* (Figure 4). *Cycas revoluta* is an example of a seed with a large, well-developed embryo that is nearly

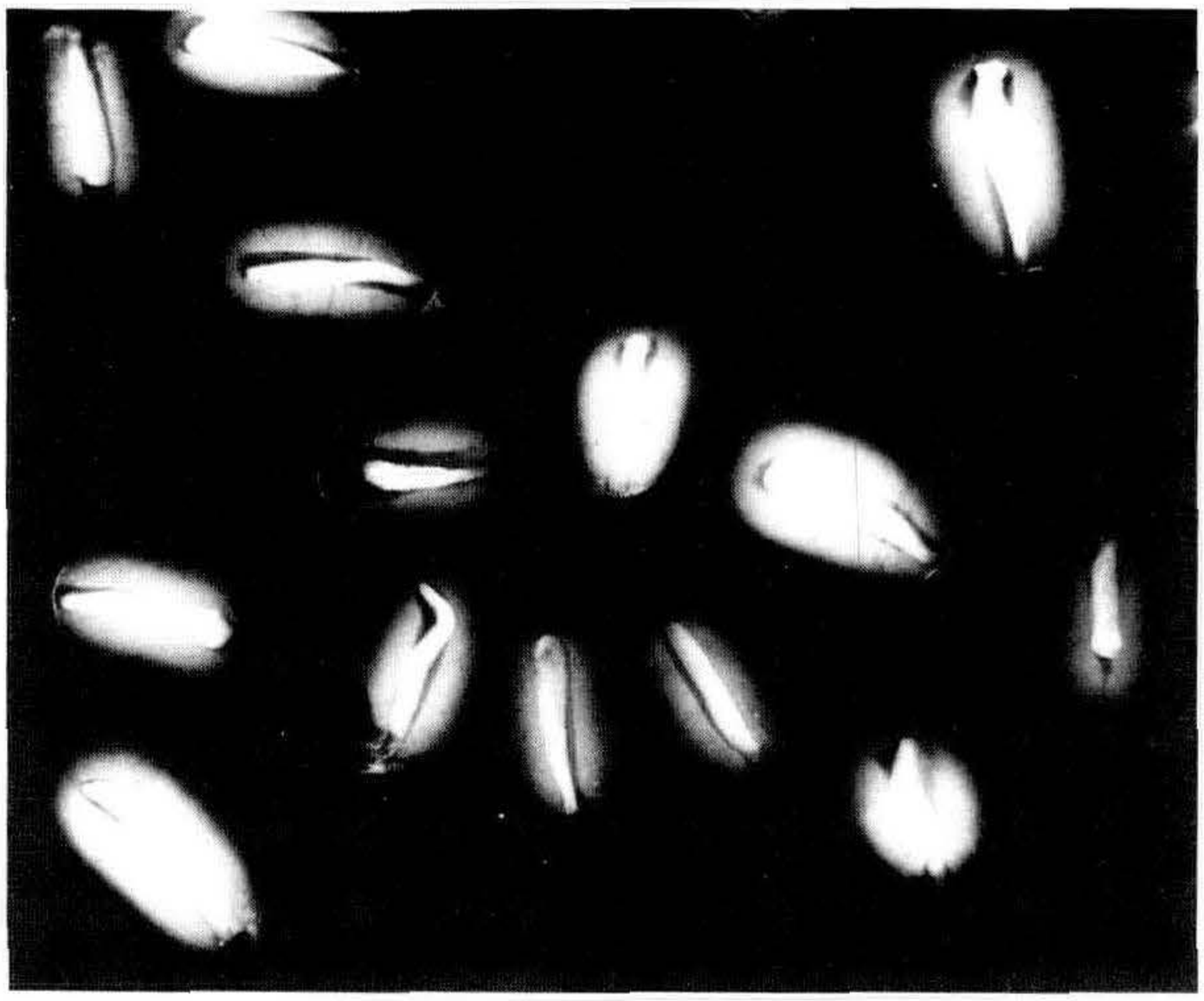

Figure 3. X-radiograph of *Strelitzia nicolai* seed. Distorted and abnormally small embryos are evident. The two seeds in the upper right center have a normal appearance.

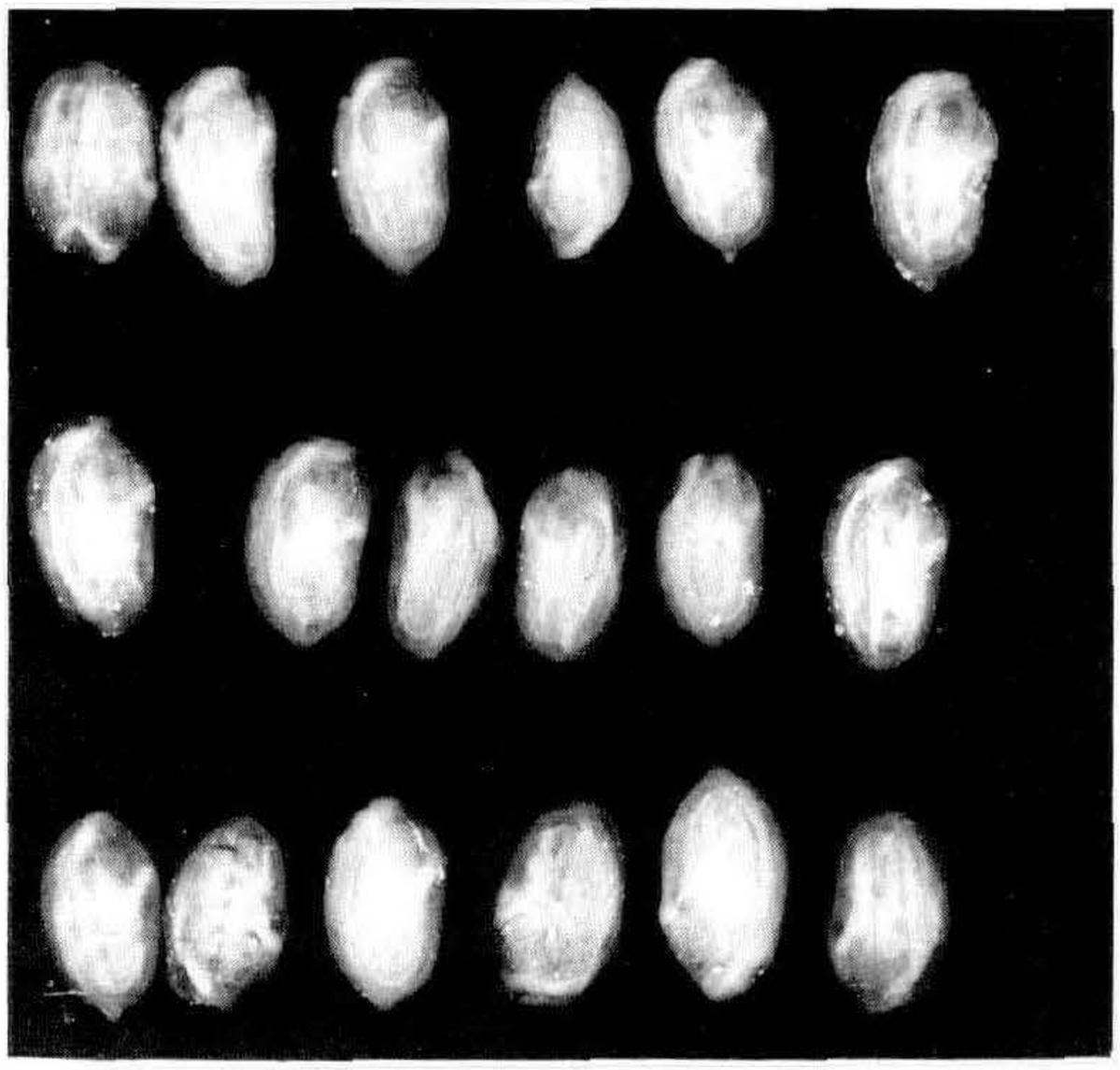

Figure 4. The thick and convoluted surface of the seed of *Harpephyllum caffrum* obscures the internal structure and diminishes the value of radiography as a quality control test.

invisible in a radiograph because of the thick, fleshy endosperm that surrounds it. *Asparagus plumosa* is a smaller scale example of this same characteristic.

Nonetheless, there are many kinds of seeds used in ornamental plant propagation that do produce clear X-radiographs. The commercial propagator might consider X-ray of seed for two reasons: First, as a quality control test for seed lots either purchased or collected from stock plants available to the propagator. If the radiograph clearly indicates poor quality the propagator may refuse to purchase or decide not to sow. Second, as an aid in producing the desired number and density of seedlings by adjusting the sowing rate in accordance with the proportion of sound seed in the radiograph.

Radiographs give only indirect indications of seed viability. Users of the X-ray technique should, in the beginning, run coincident viability tests; either germination or tetrazolium tests. Actual emergence in seedling flats should be compared with predications made on the basis of the radiographs. In this way a clear correlation between X-ray soundness and seed viability can be established for each species of interest.

To establish an X-ray testing capability would cost on the order of $10,000 Very few producers or users of horticultural seed could justify this level of investment. A relatively inexpensive alternative is to employ the services of appropriately-equipped seed testing laboratories.

While there may be others, the Oregon State Seed Testing Laboratory at Corvallis, Oregon is geographically the closest to Western nurserymen. A second is the Eastern Tree Seed Laboratory in Macon, Georgia. While neither of these two laboratories has wide experience with ornamental plants, each is well equipped and available to perform a full spectrum of seed quality tests. The few dollars spent for testing a seed lot is a small cost if it prevents sowing a large seedling crop that fails to germinate

SUMMARY

As long as seed has an important role in the propagation of ornamental plants, the propagator will be concerned with the cost and quality of seedling production. Knowledge of the quality of seed can reduce the time, space and labor required for seedling production. Several quick tests of seed quality are available The X-ray test is among the quickest and easiest to perform and provides a measure of the soundness of many seeds of horticultural interest. It is inexpensive and non-destructive to the seed. The cost of equipment generally confines performance of X-ray testing to users or producers of large quantities of seed or to

laboratories providing seed-testing services. Such laboratories are available in the Eastern and Western United States.

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MODERATOR ED SCHULTZ: We now have time for some questions for our speakers.

BRUCE BRIGGS: On heat radiation in greenhouses, how do you deal with the problem in a double poly house when you begin to accumulate snow — how do you melt the snow off?

CHARLES HOAGLAND: I think Bruce is wondering if there is any heat at the top of the poly house covered with snow. We will not have as much heat at the top of an infra-red heated house as in a unit heater system but the heat will be there. We have in Washington State many, many snowfalls, some 8 to 10 inches, and we have been able to melt the snow off the poly house with infra-red heaters.

ED SCHULTZ: You will find that the snow that accumulates on the house is an insulation material and you will get heat build-up and give you a little slight slick between the snow and the glass or the snow and the fiberglass or poly. That helps let

the snow slide down if there is any slope.

VOICE: In the tissue-cultured rhododendrons, when you took the clumps to root that had callus, did you use bottom heat and mist? What were you planning to do?

BOB TICKNOR: Did we use bottom heat and mist? The answer to both is no. We were working under lights in a basement; we were not using bottom heat. We put a poly tent over them to hold the humidity in. The radiation temperature was about 80°F under the poly tent.

RALPH SHUGERT: Jay, when you take a lot of stratified seed, let's say *Taxus capitata*, which normally needs 12 months stratification, can you put the seeds under X-ray and determine from that about what stage the seed is in during the period of stratification? Is it ready to germinate, in other words?

JAY ALLISON: You could if there was some evidence of the embryo beginning to swell, for example, a root radicle just ready to emerge through the seed coat. I might add about testing of stratified seed is that if the seed is totally imbibed with water or even an empty seed coat that is filled with water, water will have about the same absorbance of X-ray as the endosperm or the embryo of the seed. Often it is found to be beneficial in X-raying seed that has been fully imbibed or stratified for a long period of time to partially dry the seed before running an X-ray test This will bring out the detail of the embryo much better.

RALPH SHUGERT: X-ray tests could well be used along with a cutting test. If I made a cutting test on *Taxus capitata* seeds, for example, that were stratified 8 months, the cutting tests might show 80 to 85% good seeds. Then if I sent the seed to a lab — and the X-ray report then came back, I would then have, conceivably, information that would allow me to plant three months earlier than I normally would.

JAY ALLISON: Yes, very definitely.

CHET BODDY: I would like to know from Bill Nelson about that bottom heat system. What is the material that the copper pipes ran through?

BILL NELSON: That was in concrete. That was in Don Dillon's propagation beds. I am not using any circulating water; mine is strictly radiation from the water that has been heated. I want to mention a book called, "Solar Living Greenhouse Digest," printed in Arizona. It describes a lot of new materials that are coming into the forefront in solar heating. One of them is the very inexpensive series of tiny pipes, tubes of polyethylene, black poly; it looks like a real way of saving money because copper is just sky high. With the success that Don reports it is probably a good investment though, but I would have tried some of these

other materials. Hines Nursery, I know, has tried a number of kinds of polyvinyl chloride (PVC) pipe that did not work but they finally found one in the East where they use it for melting snow or ice on the roadway. That one was, apparently, very effective.

JOLLY BATCHELLOR: Twenty-five years ago there was a philodendron grower in the Pacific coast area who had the idea of running hot water through pipes in his propagation bed.He did that and had beautiful results except that the electrolysis ate the pipes up.

BOB TICKNOR: Several growers in the Oregon area are using hot water for their propagation bed heat source.

JOLLY BATCHELLOR: What kind of pipes are they?

BOB TICKNOR: Klupengers use galvanized pipe. John Mitsch uses some type of polyethylene. John just had a big installation put in, using a heat pump as a hot water source. He also has solar panels that go into the same storage reserve. He has a 20,000 gallon tank to hold the water and pipes go under the beds. He has a 100′ × 100′ greenhouse heated that way.

ED SCHULTZ: John is using low temperature, like 80° to 100°F or less. It may have some effect on the electrolysis, I don't know. I think he is using PVC pipe.

JIM SAHLSTROM: We use a drip tubing that is used for drip irrigation. Unfortunately, we heat with electricity, but we use a hot water heat element screwed into a 2-inch tee. We heat the water to about 80°F which goes into a manifold having about 9 pipes, and we send this down the house about 90 feet. The nice thing about plastic pipe is that it is a poor conductor of heat, but copper is a good conductor of heat; you put hot water in at one end and you get cold water at the other. But by putting hot water in at one end of this flexible plastic tubing, you have the same temperature at the other end. So we can put hot water in, pump it through the system, when it gets to the far end of the greenhouse we cross over, heat it up again, but it is already warm. Send it back to the other side of the greenhouse through the system again; it is a round-robin system. The type of tubing is flexible, and we work on benches that are right on the ground so we can step right on the tubings or run over them with our equipment. No problem with breaking or corrosion.

VOICE: Referring to Jim's statement that hot water running through a piece of copper tubing cools off by the time you get to the other end, I don't think that is because of the copper tubing; I think it is because of the design of the system. Circulating the water with a pump you could arrange to have the same temperature at both ends of the bed.

JIM SAHLSTROM: That is correct, but copper does cool off

a lot faster than poly though.

ED SCHULTZ: But you could correct it by increasing the speed of the water going through.

CONIFER AND MAGNOLIA GRAFTING

RICHARD H. WELLS
Monrovia Nursery Co.
Azusa, California 91702

The "upright" junipers are some of the most sought after plants we grow at Monrovia Nursery. The high demand for these plants is in part maintained by the difficulty in producing them in large quantities. Although some can be successfully and economically grown from cuttings, many others must be propagated by grafting. The types of junipers we graft are mostly cultivars of *Juniperus scopulorum*, some of which are: 'Cologreen', 'Gray Gleam,' 'Welchii,' 'Tolleson's Weeping' and 'Wichita Blue.' Except for the use of different understocks, the methods for grafting our other conifers are the same as those used for the junipers. Since the grafting of our *Magnolia grandiflora* types coincides closely with that of our conifers, their production will also be described in this paper The cultivars of magnolia we are now grafting are: 'Majestic Beauty,' 'St. Mary' and a USDA introduction called 'Little Gem.'

JUNIPERS

Understock: For good results, it is important to start with a good, vigorously growing understock. There are three we commonly use: *Juniperus chinensis* 'Hetzii', *J. virginiana*, and *J. virginiana* 'Skyrocket.' We like to use 'Skyrocket' because it is less susceptible to the various fungal diseases which can infect *J. virginiana*. Also, 'Skyrocket' produces a straighter, more graftable understock than 'Hetzii.'

The 'Skyrocket' are rooted as cuttings and then are potted into liners They will be ready to graft approximately two years from the time the cutting was made. About three weeks prior to grafting we start preparing the understock. This preparation consists of: 1) sorting for size, (5 to 7 mm in diameter is desired), 2) pruning up the sides in order to clean the working area for the graft, (an area of 7 to 10 cm starting at soil level and extending upward), and 3) pruning the tops to reduce foliage and create a uniform appearance. This process is started approximately the first week of November. One week prior to grafting, the under-

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stock is brought into the greenhouse and watered thoroughly. Within a week they are actively growing and ready for grafting. They are sprayed with Physan disinfectant and allowed to dry prior to grafting. Grafting continues through mid-January.

Scionwood: We have a crew of four who collect the scionwood daily. Most of the wood comes from our 5, 7 and 15 gallon containers. We also get some scionwood from stock plants which are planted throughout the nursery. However, the wood collected from the containers yields better percentage of "take." This is probably due to the fact that the plants in the containers grew more actively during the previous year than the stock plants, thereby yielding scionwood that is more vigorous, has better caliper, and is cleaner.

The scionwood is brought into the greenhouse where it is prepared for the grafters. We use mostly tips which are 12 to 15 cm in length. They must have 4 to 6 cm of brown, partially matured wood at their base. All side growth on the lower 6 cm of the scion is removed to provide a clean area for the grafters to make their cuts. The softer growth on the tip of the scion is also removed. This is done by pulling or tearing rather than cutting because if the tips are cut, it will result in brown necrotic areas. Such areas are more likely to become diseased in the high humidity and temperature they will be exposed to. The scionwood is then washed and disinfected in a solution of 200 ppm Physan, placed in plastic bags, and stored in a cooler at 3° to 5°C (38° to 40°F). We try to use the scionwood within 2 to 3 days. It can, however, be kept quite successfully for as long as one week.

Grafting Technique: The type of graft we use on our conifers is the basic side graft. The understock is the first to be cut. Starting at a point as low as possible on the stem, a longitudinal incision of about 30 to 35 mm is made. The cut ends at a depth of about ¼ the diameter of the stem, therefore leaving a flap. An 80% isopropyl alcohol solution is used to disinfect the knife between cuts.

On the scion, we first make a longitudinal slice of about 30 mm on one side, and then we make a second, slightly shorter, parallel slice on the opposite side. It is important to leave a small strip of undisturbed bark on each side of the scion. The strip of bark on one side should be slightly wider than the other. This wider side is used to match cambium layers with the understock. If the scion is not wide enough to match with the understock on both sides, having the second side of the scion slightly narrower will allow the flap of the understock to close more fully. We also cut a small wedge at the base of the scion to remove the very thin wood which could be more subject to desiccation.

After the scion is properly inserted into the understock, the

graft is wrapped with a budding strip (¼ in. by 4 in), applying a medium tension. The wrapping begins at the top of the graft and finishes at the bottom with a half-hitch so the strip can be later easily removed. No tar or wax is used.

Grafting Tents: When the graft is completed it is then placed into a "grafting tent." This consists of a raised bench with a plastic quonset-type covering. This tent provides an environment of high humidity and relatively warm temperature for the grafts. The tent is prepared in the following manner: first, the bench top is covered with waxed paper, and then a three inch layer of peat moss (treated with Captan) is placed on the paper. The benches have 3 to 4 in. side walls which prevent spillage of the peat moss. Over the bench is built a small quonset-type structure which supports a poly cover. Under the bench there are hot water pipes which provide warmth for the grafting process. To help reduce foliage fungus problems, we install a small convection tube within the tent. This keeps the air circulating, which helps to prevent water condensation. Thus, we can maintain a warm, high humidity environment while the foliage of the plants and the graft unions themselves are not overly wet.

The method of placing the grafted plants into the tent is regulated closely. The pots are "plunged" into the pre-moistened peat moss, in rows, at about a 60° angle, with the graft unions on the top side. This is done to prevent water from sitting on the graft unions. Any condensation which forms or drips on the grafts quickly runs off due to the angle. Also, with the graft unions on the top side, they get better air circulation and light which helps to prevent disease. The pots are plunged to a depth so that the peat moss holds them at the proper angle, but not so deep as to have the peat in contact with the graft unions.

Prior to placing the grafted plants in the peat moss, the peat is made wet to the run-off point. Also, prior to grafting the understock is thoroughly watered. These steps are important because once the grafted plants are put in the grafting tents, the tents are closed and sealed. Just prior to sealing the tents, the beds of new grafts are sprayed with Benlate as an extra precaution against disease. The tents remain closed for two weeks.

Hardening-off: Within two weeks, as many as 25% of the grafts are ready to be removed from the tents. We watch for new growth on the scions, and when this growth is 5 to 10 mm in length the graft is removed from the tent and hardened off. The majority of the grafts will have been removed within a 5 to 6 week period. After the initial two week period, we start spraying all tents and new grafts on a weekly basis with a fungicide. We normally alternate spraying with Benlate, Dithane Z-78, and Mertec.

When the grafts are removed from the tents they are placed on open benches in the greenhouses. Here they are sprayed with water several times a day to prevent drying. They are kept in the greenhouse under these conditions for an additional two week period, after which they are moved outside to a shaded area. At such time, spraying, or misting, will continue for approximately a month, during which period the frequency of spraying is gradually reduced. During this hardening-off time it is necessary to keep the foliage of the understock cut back to encourage growth of the scion.

Canning: We start to can the new grafts into gallon containers during early to mid-March. Several weeks prior to canning the understock is removed completely. The grafting strip is left to protect the graft during the canning operation but is removed within one month after canning to prevent girdling. By the following December, the plants will be 18 to 24 in. in height.

MAGNOLIAS

Understock: We use one gallon *Magnolia grandiflora* plants, (which take about two years to reach a suitable size), for our understock. Because of the large diameter of the scion (10 to 12 mm), we must use understock of at least equal size. In September or October, all of the one gallon understock is pruned to a height of 24 in. This assures uniformity within the grafting tents later. The understock has usually been staked to help produce a straight stem and working area.

In the first part of November, as soon as there has been some cold weather, we begin to bring the understock to the greenhouse area, where it will be prepared for grafting. The stake, all of the side branches, and most of the leaves will be removed, with only a few leaves remaining at the top. The understock is also sorted for proper size.

The plants are then brought into the greenhouses, watered thoroughly, and placed, can tight, into grafting tents. These tents are nearly the same as those used for the junipers, except they are taller and have only a thin layer of peat on the bottom. The bed of understock is sprayed with Physan and allowed to dry before grafting.

Scionwood: All scionwood is collected daily from trees planted throughout the nursery. The stock plants are watched closely to ensure healthy scionwood production. We use only tips or terminal ends which are cut 20 to 25 cm in length. All foliage is stripped from the scions and they are disinfected in a bath of 200 ppm Physan. They are then placed in plastic bags and stored in a cooler at 3° to 5°C (38° to 40°F), until needed. We try to use all scions within three to four days.

Grafting Technique: The technique for grafting our magnolias is the same as that used for our junipers, except with the magnolias we are dealing with larger scion and understock. The longitudinal cut in the understock will be 5 to 6 cm in length, ending at a point about ¼ in diameter of the stem. The cuts on the scion will also be about the same length, but the width of the bark between the cuts must be much thinner (about half the thickness) on one side. As with the junipers, the cambium of the wide side is matched with the cambium of the understock, and unless both sides can be matched, the flap lays over the narrow side. The graft is wrapped from the top down with medium tension. A wide (⅜ in. by 8 in.) rubber strip is used, with a half-hitch placed at the bottom.

When we finish grafting a bed, the plants are sprayed with Benlate and the plastic cover is sealed on the tent and remains closed for two weeks.

By the end of two weeks, the first signs of growth on the scions are observed. The terminal buds begin to swell and pop off their caps. Within another week or two, they will start to unfold their first leaves When the plants have one or two fully opened leaves they are ready to be removed from the tents. We observe the same fungicidal program as with the junipers.

Hardening-off: The magnolias are hardened off in the same manner as the junipers. They are first placed on an open bench within the greenhouse, where they are misted as needed for two weeks. They then are moved outside to a shaded area where the misting continues for an additional month.

Canning: The transplanting of the gallon grafts into five gallon cans is done between March and May. It is best to have all of the plants canned prior to the hot weather. Unlike the junipers, the magnolias are canned with the understock still present. This is done because the foliage of the understock shades and protects the tender new foliage of the scion. Near to August, the understock is removed completely after the scion has had a chance to grow and "toughen up." It is not necessary to remove the rubber strips since their exposure to the sun quickly weakens them and they break off.

A PROCEDURE FOR PROPAGATING FERNS FROM SPORE USING A NUTRIENT-AGAR SOLUTION

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Plantlet crowding and biological contamination are problems experienced by many who propagate ferns from spore. At Bordier's Nursery, our attention has been directed toward finding propagation methods which would work to diminish these problems. The methods we are now using are not uncommon. They require tedious labor with cleanliness being stressed at every step, but they are successful in that we are able to produce the fern liners we need. Briefly, our propagation procedure involves germinating spore and growing the young fern gametophytes on a nutrient-agar solution, transplanting adult gametophytes onto a growing medium where fertilization can lead to fern sporophyte formation and finally, transplanting young sporophytes to give them space to develop into liner-sized plants. Previously, we germinated our spore on fine spagnum peat and had a serious problem with gametophyte crowding, as well as fungal, algal and moss contamination. However, approximately 1½ years ago, we tested and adopted the use of a sterile nutrient-agar solution as a germination and growth medium, a method developed by Tjosvold (1) specifically designed to reduce these problems. The six fern species we produce using our method are: *Cyrtomium falcatum* 'Rochfordianum', *Dicksonia antarctica, Nephropelis exaltata Polystichum setosum* (*P.* × *bicknelii* or *P aculentum,* Bot. ed.) *Rumohra adiantiformis* and *Sphaeropteris cooperi.* Following is the procedure we are successfully using to propagate ferns from spore.

Our spore is collected from stock plants when the sori on the underside of the fronds are plump and ripe, but before these clusters of sporangia have discharged their asexual contents. These fronds are gathered, enveloped in paper plant sleeves and placed in a warm, dry location for two weeks. This desiccating environment dehydrates special cells encircling each sporangium, eventually catapulting the spore away. It is important to separate the released spore, as much as possible, from the crisp fronds and chaff that may carry inocula. A mechanical shaker and a series of soil sieves are used for this separation, the final two screens having a 200 and 270 mesh (75 and 53 micrometer openings, respectively). The powdery spore is stored dry in tightly sealed containers and refrigerated at 4.5°C (40°F).

From this point on, cleanliness becomes very important, especially when working with a sterile growth medium. Any con-

tamination which can be avoided leads to more productive spore germination, more vigorous gametophyte growth and fewer problems in the transplant flats. In our greenhouse, a laminar-flow hood provides us with an inocula-free work space in which to conduct our sporing. Precautions taken to insure cleanliness within the transfer hood include spraying the working surface, walls and filter with aerosol Amphyl and operating the filter 30 minutes prior to use. Cleanliness is enhanced when sporing is conducted atop disinfectant saturated paper towel. In addition, all sowing instruments are cleaned in a 5% Clorox solution.

Our spore is sterilized immediately prior to sowing to insure that it is free of biological contamination that may have passed along with it through the soil sieves. One part spore is shaken vigorously in 5 parts of a 5% Clorox solution. After 1½ minutes this mixture is quickly poured into a Buchner funnel-filter setup and with the aid of a vacuum, rinsed several times with water. This dilutes the biocide so harm to the spore is avoided. After rinsing, we allow the vacuum to pull air through the spore for an additional 5 minutes before letting the spore air-dry under the hood. If this vacuum airing is not done before drying, caking of spore results.

Tjosvold was trying to accomplish two things when he developed his method of sowing fern spore on a warm nutrient-agar solution. He wanted to improve the distribution of spores on the sowing medium to reduce gametophyte competition and provide a nutrient-rich environment free of contamination from fungi, algae and mosses. He found that by using an agar concentration of 2 grams per liter of double strength Hoagland solution #2 in combination with a solution temperature of 120°F at the time of sowing, a favorable surface tension occurred which distributed the spore uniformily on the medium. Gametophyte growth was enhanced when the strength of the Hoagland solution was doubled. Heating to the boiling point involved in preparing the solution produced a sterile medium on which the fern gametophytes could grow without competition. Our nutrient-agar solution is prepared by Soil and Plant Laboratory, Santa Ana, California, according to Tjosvold's formula. We receive this solution after it has been autoclaved and sealed in Mason jars.

Prior to sowing, we reheat the prepared solution in a hot water bath shaking the quart jars several times to insure a homogenous medium. After it has cooled to the desired sowing temperature of 120°F, each sterile, plastic, 100 × 200 mm petri dish is filled with ¼ inch of the solution. Sowing is done by lightly tapping a 270 mesh screen containing the spore over the medium, quickly replacing the petri lid when finished. A key advantage to sowing on this medium as opposed to peat moss is that one can see the individual spores sown due to the color contrast and

clarity of the solution. If density appears to be low, more spore can be added.

After sowing is completed, a flame is used to sterilize the exposed edges of the petri dishes. This extra precaution is taken to eliminate inoculum that may have been introduced with handling and could find its way into the plate. These petri dishes are then placed and sealed in polyethylene bags to minimize dehydration of the solution and keep out fungus gnats and other insects.

Germination of spore usually occurs within 10 to 14 days, the gametophytes appearing as little green dots on the solution. For germination and growth, our fern house daytime temperature is kept between 21° and 26.5°C (70° and 80°F), and cooled by means of an evaporative cooler. Night time temperature is maintained at 18.5°C (65°F). Light intensity is kept in the range of 200 to 400 foot-candles.

Two or three months after germination, gametophytes are usually ready to be transplanted. Transplanting is done because the small plants have grown to a desired size and conditions more conducive to fertilization for sporophyte formation are needed. On the underside of the adult gametophyte, motile sperm from male antheridia are attracted to eggs within female archegonia by a chemical substance. Watering and misting the transplant flats provide free water in which the multiflagelate sperm can swim to their destination. We have noticed reduced numbers of sporophytes when adult gametophytes are kept on the more viscous nutrient-agar solution for a long period of time. Transplanting is also needed when gametophyte crowding starts to retard growth. This occurs after the young gametophytes have spread over the solution to the walls of the petri dish.

At the time of transplanting, gametophytes in petri dishes are floated on water, broken apart and spooned with water onto a prepared flat. Usually 10 to 20 gametophytes are spooned together in a group with groupings spaced about an inch apart. We also transplant by combining the contents of several petri dishes, diluting and agitating with water, and pouring this mixture over the prepared flat until the desired gametophyte density is obtained. The water used in both of these transfers permits a close contact between gametophyte rhizoids and the growing medium. Our transplant mix consists of equal parts of fine peat moss, fine vermiculite and graded, sand-sized perlite. All flats are kept moist with a ⅓ strength Peter's solution (20-20-20) made from chlorinated water low in salts. Flats are placed on a bench beneath a polyethylene tent to maintain high humidity.

Sporophytes start emerging from the adult gametophytes 3 to 7 months after transplanting, depending on the species. These

sporophytes are transplanted as single plants to another prepared flat while the second leaf is still developing. The transfer is made at this young stage to avoid the root intertwining that is characteristic of older sporophytes that have grown closely together. There is reduced root tearing when intertwining is minimized. Plastic tweezers are used for the delicate separation and placement into flats and care is always taken to keep the fern crown above the soil level. As sporophytes become large enough, they are finally potted into liner containers, again keeping the crown above soil.

While our transplanted ferns are vigorous plants seemingly tolerant of fungi, algae and mosses, inoculum are ever present and cause serious problems if left unchecked. Spacing for adequate air circulation, proper irrigation using water free of inoculum and transferring only clean plants to transplant flats reduces or prevents some of these problems. Removal of diseased and infested areas is done by hand. Problems that are present in petri dishes are easily elimated by throwing away contaminated plates. We are quite inexperienced when it comes to chemical control, but have found that tender young gametophytes and sporophytes are easily burned by particular chemicals in combination with our greenhouse temperatures and humidity.

Germinating spore and growing gametophytes on nutrient-agar solution has improved our fern propagating procedure. The transplanted gametophytes are vigorous plants having grown in a medium free of contaminants, uncrowded, and well supplied with nutrients. We rely on the vigor of these transplanted gametophytes along with cleanliness and proper cultural care to provide and maintain the sporophytes required for our canning production.

LITERATURE CITED

1 Tjosvold, Steven 1978 Uniform fern spore dispersal on warm nutrient agar solution University of Califoria Nursery and Flower Report Summer, 1978 p 7

MAHONIA PLANT CONDITIONING AND PROPAGATION

CHET BODDY

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Of the four mahonia cultivars we grow, *Mahonia aquifolium* 'Compacta' is the most popular — and also the most difficult to propagate from cuttings. This paper deals mainly with 'Com-

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pacta', but the same principles apply as well to our other cultivars: *M. a.* 'John Muir', *M. a.* 'Golden Abundance', and *M. pinnata* 'Ken Hartman.'

Stock Field Management: All of our mahonia stock plants are field grown in the full sun, in an acid loam, soil. The climate of the northern California coast, with foggy summers and mild rainy winters, favors the growth of our cutting wood. In other climates, stock plants might benefit from shading. We take 'Compacta' cuttings from a ½ acre stock field which is over 15 years old. Because 'Compacta' is a slow-growing cultivar, reaching only about two feet in height, we find it especially important to maintain a stock field to produce enough cuttings.

I prune the stock fields hard during their winter dormancy, in order to keep the plants in a "juvenile" state, and to produce more uniform cuttings. Juvenile wood seems to root more readily than older wood, and produces less flowers which may inhibit rooting. The best cuttings are taken from wood that is two years old.

Although weeds and insects can be a problem in the stock fields, I avoid using herbicides or systemic insecticides which might remain in the plant tissues and inhibit rooting. This year, we are having some success with cultivating, mowing, and mulching for weed control. The stock fields are fertilized monthly (following the advice of an annual soil test) and watered overhead weekly during the growing season. Plants which are well nourished produce the best cuttings.

Rooting Factors: We begin taking mahonia cuttings in the fall as soon as the wood has hardened-off. We begin 'Compacta' in September, 'John Muir' and 'Golden Abundance' in mid-October, and 'Ken Hartman' in November. These dates are relative to our Pacific Coast climate; the condition of the wood should determine when to take cuttings in other areas.

All of these cuttings except 'Ken Hartman' require a "heel" — the woody annual growth scar — at their base, from which the roots emerge. At least three compound leaves are required on each cutting, preferably in the form of a tip, for even root formation. If only one compound leaf is left on the cutting, roots will tend to emerge in a longitudinal row beneath that leaf, even if the cutting is six inches long. The length and caliper of each cutting may vary, but a heel and sufficient leaves are always included. Larger cuttings tend to produce more vigorous plants.

'Compacta' cuttings require a well-aerated rooting medium, although our other mahonia cultivars can tolerate more moisture. This year, I am using a 1:10 peat/perlite medium in well-drained plastic flats which are 2½ inches deep. This mix has given better results than higher proportions of peat/perlite and various ver-

miculite/perlite mixes, which tend to retain more water. Certain grades of pumice and sand provide suitable aeration as well, but are not available in our area and would be heavier to handle. A deeper flat would provide better drainage, but we are using the shallower flats to cut costs.

We sanitize the cuttings in a 200 ppm solution of Physan 20 disinfectant, and then dip them in a Hormex #8 (.8% IBA) rooting powder. We stick the cuttings 100 to a flat, stamping each flat with a wooden pegboard template for speed and uniform spacing The cuttings are sprayed regularly with a Captan/Benlate fungicide mixture.

Mahonia cuttings require a low-stress environment for their leafy tops. If stressed by heat, bright sunlight, wind, or dryness, the leaves may redden and drop before the cutting can produce roots. We place our cutting flats on the gravel floor of 12×96 foot quonset structures covered with 50% polypropylene shade fabric. Fiberglass panels form 3 foot high lateral wind screens. At the outset, the cutttings are misted during the day at 10 minute intervals for 10 seconds duration. The mist is later reduced or eliminated as weather permits.

I have had difficulty finding the right mist head for use in our propagating quonsets. Greenhouse mist foggers are not suitable for outdoors — the mist blows away in the slightest breeze. Plastic spinner sprinklers put out too much water and saturate the rooting medium. While visiting Hines Nurseries in Santa Ana, I discovered a mist head manufactured by Spraying Systems Co. of Wheaton, Illinois, which is ideal for my use. It is a solid brass "whirljet" extra wide spray nozzle ¼ E series, which puts out a nearly flat hollow cone of mist at least 10 feet in diameter.

'Compacta' cuttings do not require additional bottom heat if taken in September, while the medium naturally reaches temperatures of 15° to 18°C (60° to 65°F). The first cuttings we take will produce roots within 3 to 4 weeks. These roots will grow throughout the winter, even though the medium partially freezes. However, as the weather gets colder, new root formation on the unrooted cuttings ceases. If these late cuttings survive the winter without defoliating or becoming diseased, they will root the following spring when the weather warms up again. Our other mahonia cultivars will root in our mild winter climate (which rarely drops below freezing) without additional bottom heat.

I am constructing a hot water bottom heat system in one of our quonsets with the hope of increasing the rooting of 'Compacta' cuttings in the fall. I think that the lack of bottom heat is still a major limiting factor affecting 'Compacta' rooting, but I will not know for certain until my bottom heat system is in

operation.

Growing in Four-Inch Pots: 'Compacta' cuttings break dormancy and leaf out in mid-April, after spending as long as 7 months in cutting flats. The other mahonia cultivars, because of their shorter dormancies, can be stuck later and potted earlier. We dig the cuttings, prune the roots, and put the plants into 4-inch pots as soon as they begin to leaf out. Our potting mix is primarily coarse fir bark (⅛" to ¼"), with some lava rock, and fertilizers added. Mahonia roots require good drainage, and finer grades of bark tend to decompose more rapidly and lose their porosity. Blending a good micronutrient formula (such as Micromax) into this coarse soil mix has given us excellent results this year.

We grow the 4-inch pots in lathhouses under 30% shade, with an overhead watering system. We begin fertilizing by the hand watering method as the plants are potted, and continue this weekly throughout the growing season. Fertilizer is injected into our water system through a 1:200 proportioner. We used to fertilize through our overhead system, but found that the savings in fertilizer through hand watering was greater than the added labor cost. Also, the plants respond much better to this method.

Undersized rooted cuttings are "restuck" back into the propagation flats, moved into the lathhouse, and watered and fertilized the same as 4-inch pots until they are ready to be potted.

CALIFORNIA NATIVE PLANT PROPAGATION

PEGGY S. McLAUGHLIN

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Several years ago, the western part of the U.S. experienced a drought of serious magnitude, and of a severity and duration not uncommon in our natural history. Even as the rains returned to normal, we continued to remind ourselves that a drought can and will occur again. One of the most severely affected portions of our lifestyle was our landscape — lawns died and were replaced by drought resistant groundcovers or dry rockscapes. Water loving plant materials were difficult to sell to the homeowner. And one horticultural trend gained momentum — the use of California native plants in the landscape.

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many gardens in the West planted 20, 30 and even 50 years ago reveal examples of these natives in well established situations. Even more surprising — Kew Gardens in England has some of the finest examples of California native plants being grown in a man-made landscape. These were collected beginning several hundred years ago when European botanists explored our terrain. Clearly, we were not the first to recognize the potential of these active specimens. Now that the threat of drought is not imminent, although the reality of skyrocketing water costs are every-present, what has become of our interest in California natives?

Few articles in popular gardening magazines expound the virtues of natives. Nursery advertisements rarely feature them. Landscapers are not frequently planting them. In fact, an informal survey of retail nurseries in Southern California revealed that although there continue to be inquiries about native plants, few nurseries carry them. When they do it is the common selection — coyote bush, carmel creeper, and Oregon grape. Several nurseries responded that they had always carried natives — oleander, eucalyptus and rosemary! As these are non-native, albeit common, plants found in California, our definition of a "native" plant is either misinterpreted or is incorrectly applied by some individuals.

What appears to be the real problem, however, is the "chicken and the egg syndrome" we see regarding supply and demand: retail nurseries, landscapers and the public are not always aware of the existence of native plants, much less knowledgeable about their culture. They rarely request them of the wholesaler. The wholesaler, therefore, grows few natives. When there are requests, often for large quantities for landscape contracts, not enough of the plants are available. Disillusionment occurs and requests may dwindle. So we are caught in the dilemma of erratic demand and uneven supply. Hardly a condition to bolster a successful trend! There are, however, continual attempts by many nurseries to produce quality native plants. It can be an extremely frustrating adventure.

Seed propagation of native plants can be very successful. Certain species, such as oaks (*Quercus*), and pines (*Pinus*) grow readily from seed and are sturdy container plants. Others, however, such as certain manzanitas (*Arctostaphylos*), *Ceanothus*, and bush poppies (*Dendromecon*) have evolved elaborate dormancy requirements that must be discovered and broken. These dormancies, while protecting the plant populations from fire, drought, and flood, do make the plants very difficult to grow commercially. In other cases, viability can be low. Germination is spotty and resulting plants may be weak and spindly and not at all uniform.

Cutting propagation can solve some of these problems in that difficult germination can be bypassed. Of course, the many new cultivars of *Ceanothus* and *Arctostaphylos* require vegetative propagation to retain their ornamental characteristics. Uniform stands of vigorous rooted cuttings reward the careful propagator. But there are considerations that must be addressed in order to be successful.

Many propagators report that root formation is sometimes very slow for crops such as *Arctostaphylos*, Pacific wax myrtle (*Myrica californica*), mahonia (*Mahonia*) and toyon (*Heteromeles arbutifolia*). Naturally, the longer cuttings remain in the propagation environment, the greater the incidence of disease. Decay problems are quite common and can spread rapidly through the flats of nonvigorous cuttings. Adding to the problem of slow rooting is the fact that many cuttings defoliate under prolonged mist. When rooting finally does occur, a weakened cutting, with no leaf surface, may not be able to survive in the liner stage.

What factors cause the slow rooting problem that enhances the onset of disease? One answer may be the critical timing necessary for the collection of cutting material. It seems that the time of year and the age of wood used are of great significance when propagating native plants. The most desirable months are October through April, which approximates the growing season of natives. Generally softwood cuttings are the most successful. However, each cultivar must have its own peculiar requirements for optimum cutting success. Add to this difficulty the fact that cutting material is often not readily available and it is clear that success with cutting propagation requires planning and patience.

Once successful propagules are obtained from either seed or cutting, there are some difficulties encountered in growing on the containers to saleable size. Natives in cans are as sensitive to overwatering as they are in the landscape. Root decay organisms can strike quickly. Container soils must be fast draining, yet provide a moisture reservoir for the delicate roots which may be few in number. Water quality can be a factor; salt burn shows up readily on native foliage. Air pollution damage is a problem particularly on pines, currants (*Ribes*) and some oaks.

But the strong interest in native plants has led to more experimentation in propagation. Some of the difficulties I have outlined have been at least partially overcome. The difficulties of seed dormancy can be solved by scarification of the seed coat with hot water or acid (*Fremontodendron, Arctostaphylos,* and *Ribes*). High temperature dormancies insure that seeds will germinate after a fire. To overcome this, *Dendromecon* seeds are planted in the flat and straw or pine needles are burned on top to raise soil temperature to the required level.

To enhance cutting success, bottom heat is found to increase rooting percentage, and mist in less frequent intervals than those for softer crops reduces decay problems. The use of rooting hormones in various combinations and at different concentrations requires more detailed research.

One ingenious experiment involved *Fremontodendron*, a fabulous flowering specimen that is extremely susceptible to phytophthora root decay in the landscape. To attempt a solution, *Fremontodendron* was grafted on a close relative, a *Sterculia*, to provide a more tolerant rootstock. The grafts took initially but did not survive more than two years. Hopefully future attempts will be more successful.

Even the art of tissue culture has been utilized. Certain difficult to grow native irises have been cultured to provide a more prolific propagation process.

Even with the difficulties encountered in native plant propagation, there are many successes we can observe:

— many new cultivars of *Arctostaphylos* and *Ceanothus* that are well suited to the smaller landscape can be propagated by cuttings.

— oaks and pines come easily from seed.

— native irises, coral bells (*Heuchera*) from division.

— cottonwoods (*Populus fremonti*) from seed and cutting.

— toyon (*Heteromeles arbutifolia*) from seed.

— Coyote bush (*Baccharis*) from cuttings.

— California fan palm (*Washingtonia filifera*) from seed.

— Buckwheats (*Eriogonum* spp.) hydroseeded on slopes.

— A multitude of wildflowers from seed.

There are those who may still wonder at the necessity of dealing with these plants that may not initially be economically advantageous. It seems that these plants, so well adapted to our rather harsh environments, and particularly to our long, hot, dry season, are worth the effort. They have beautiful flowering and fruiting characteristics and offer us a historical and cultural tie with our region.

They can solve many difficult landscape problems where plants are required that are low maintenance and low on water use. Revegetation of areas disturbed by highway or utility construction can be returned to near normal with natives. Fire scarred slopes can be held together with fast growing herbaceous material.

But most of all, we as horticulturists are always interested in enlarging our plant selection and in finding new and more excit-

ing members of the plant world. California natives represent a rather untapped resource for us to explore.

The outlook for the future? Hopefully the nurseries growing a few natives at the present will have greater success in the future and will add to their list. Certainly research being undertaken by institutions such as the Saratoga Horticulture Foundation, the Santa Barbara Bontanic Garden and Rancho Santa Ana Botanic Garden, as well as our colleges and universities, will help us to solve the cultural problems we face. If these plants are to be a viable part of the nursery industry, it will take a commitment on the part of those of us in the industry. I hope that you will agree that California native plants are worth the effort.

CARBONATED MIST AND HIGH INTENSITY SUPPLEMENTARY LIGHTING FOR PROPAGATION OF SELECTED WOODY ORNAMENTALS

W. C. LIN AND J. M. MOLNAR

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Abstract. Injection of CO_2 to the mist water (CO_2 mist) promoted rooting of *Magnolia soulangiana*, *Magnolia sieboldii*, *Juniperus sabina*, and *Rhododendron* 'Anah Kruschke' Daily high intensity lighting with high pressure sodium (HPS) lamps for 16 hours promoted rooting of *Magnolia soulangiana* and *Rhododendron* 'Anah Kruschke' and inhibited rooting of *Juniperus sabina*, *Juniperus squamata* and *Rhododendron* 'May Day' These results are discussed in terms of photosynthesis, CO_2, light and water

REVIEW OF LITERATURE

Plant propagation involves a great number of plants in a small production area where use of controlled environment appears to be logical. Enrichment with CO_2 and/or high intensity lighting at the time of seeding plants has accelerated the growth of herbaceous and woody seedlings (2, 9, 10, 11, 19). Modification of environments for propagating cuttings has not been studied extensively.

Many plant species or cultivars (genotypes) are difficult or almost impossible to propagate by cuttings. Previous work (14) demonstrated that rooting was improved by CO_2 enrichment of the atmosphere or of the mist (CO_2 mist). A recent report (3) described the benefits of using high intensity lighting with herbaceous cuttings, but the effects of such lighting on woody cuttings has not been widely studied (1).

Experiments were initiated to investigate the effects of CO_2 mist and high intensity supplementary lighting on rooting of

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Experiments were initiated to investigate the effects of CO_2 mist and high intensity supplementary lighting on rooting of

selected woody ornamentals.

MATERIALS AND METHODS

Two identical greenhouse compartments were equipped with intermittent mist systems. The mist at 40 psi was automatically controlled by a finely meshed "leaf" (Mist-A-Matic) moving in response to weight of moisture on its surface. The cuttings in one compartment were treated with CO_2 mist containing 900 to 1200 ppm of CO_2 using a system described by Molnar and Cumming (14). The control compartment was misted with tap water containing 200 to 400 ppm of CO_2. Both compartments were lighted by 400 W SON/T high pressure sodium (HPS) lamps mounted 1.83 meters above the propagation bench which provided 4000 lx supplementary light.

Lighting was 12 hours per day (7 A.M. - 7 P.M.) for Experiment I and 16 hours (4 A.M. - 8 P.M.) for Experiment II. The air temperatures were set at 16°C (61°F) during the light hours and 10°C (50°F) in the dark. The rooting media were maintained at 21°C (70°F) with a heating cable. There were two experiments, with different lighting hours, rooting hormones, media and genotypes, as below.

Experiment I (1978-79). This experiment was conducted to examine the rooting response to CO_2 mist with daily 12 hours (7 A.M. - 7 P.M.) of lighting. Fifty cuttings were used for each treatment. Cuttings of *Rhododendron* were treated with 0.8% IBA in talc (Seradix) and other species with 0.3% IBA. The rooting medium contained equal volumes of sphagnum peat moss and perlite.

Experiment II (1979-80). This 2 × 2 factorial experiment was conducted with 2 levels of CO_2 (with and without CO_2 mist) and 2 levels of light (with and without HPS light). Each greenhouse compartment was divided into 2 sections with black plastic film. One section was lighted for 16 hours (4 A.M. - 8 P.M.) daily. The other section was not lighted. Each treatment contained 40 cuttings of each genotype except *Magnolia*. Cuttings of *Rhododendron* and *Ilex* were wounded on one side, while the others were not. All cuttings were dipped in 0.8% IBA in talc and inserted into rooting medium containing equal volumes of sphagnum peat moss, perlite and sand.

RESULTS AND DISCUSSION

Experiment I. In general, CO_2 mist increased the percentage rooting in English holly, *Rhododendron*, *Chamaecyparis*, *Juniperus* and Douglas fir. The quality of the root system in *Taxus* × *media* and Douglas fir was also improved by CO_2 mist (Table 1).

Table 1. Effects of CO_2 mist on rooting of *Taxus* × *media* 'Brownii' and *Pseudotsuga menziesii* '162'[1]

	− CO_2	+ CO_2
	Taxus × *media* 'Brownii'	
Average number of roots per cutting	2 4	4 4
Average root length per cutting (cm)	6 3	26 0
Average root fresh weight per cutting (g)	0 18	0 57
	Pseudotsuga menziesii '162'	
Average number of roots per cutting	1 8	2 6
Average root length per cutting (cm)	17 5	20 3
Average root fresh weight per cutting (g)	0 65	0 94

[1] 50 cuttings per treatment

Experiment II. The percent and quality of rooting due to CO_2 mist and HPS lighting varied between genotypes tested.

CO_2 Mist. The CO_2 mist increased percent and quality of rooting in *Magnolia soulangiana, Magnolia sieboldii* (Table 2), *Rhododendron* 'Anah Kruschke' (Table 3), *Juniperus sabina* (Table 4), and 2 cvs of *Ilex aquifolium. Juniperus squamata, Ilex crenata* and *Rhododendron* cvs. 'May Day' and 'Elizabeth' failed to respond to CO_2 mist.

Table 2. Effects of CO_2 mist and supplementary lighting with high pressure sodium (HPS) lamps on rooting of *Magnolia*[1]

	− CO_2		+ CO_2	
	− HPS	+ HPS	− HPS	+HPS
	Magnolia soulangiana			
Percent of cuttings rooted	47	100	100	100
Average number of roots per cutting	1 9	7.2	9 3	10 0
Average root length per cutting (cm)	10	42	60	71
	Magnolia sieboldii			
Percent of cuttings rooted	100	93	100	100
Average number of roots per cutting	7 7	6 5	10 3	9 3
Average root length per cutting (cm)	55	62	87	89

[1] 15 cuttings per treatment

Among the 10 genotypes listed, CO_2 mist promoted rooting in six and did not affect four. The improvement in rooting observed in this experiment was not to the same degree as previously reported (14). The CO_2 concentrations of 900 to 1200 ppm were lower than the previous study of 1500 to 1800 ppm. It is worthwhile to note that *Ilex crenata* rooted 95 to 98% without CO_2 and *Ilex aquifolium* rooted 36 to 86% with CO_2. It appeared that easy-to-root genotypes might not benefit from CO_2 mist while hard-to-root ones would. The present study also indicated that CO_2 mist increased rooting of many plant species in addition to those studied previously (14). This CO_2 response is considered commercially important and it was recently confirmed by a commercial operator (17).

HPS Lighting. The effects of HPS lighting were less evident

than those of CO_2 mist on rooting. The HPS light increased percent and quality of rooting of *Magnolia soulangiana* (Table 2) and *Rhododendron* 'Anah Kruschke' (Table 3). HPS light reduced rooting of *Rhododendron* 'May Day' (Table 3) *Juniperus sabina*, and *Juniperus squamata* (Table 4). *Magnolia sieboldii*, 2 cvs of *Ilex aquifolium*, *Ilex crenata*, and *Rhododendron* 'Elizabeth' did not respond.

Table 3. Effects of CO_2 mist and supplementary lighting with high pressure sodium (HPS) lamps on rooting of *Rhododendron*[1]

	$-CO_2$		$+ CO_2$	
	− HPS	+ HPS	− HPS	+ HPS
	Rhododendron 'Anah Kruschke'			
Percent of cuttings rooted	25	48	78	90
Average root ball diameter (cm)	0 6	1 3	2 4	3 9
	Rhododendron 'May Day'			
Percent of cuttings rooted	90	73	100	85
Average root ball diameter (cm)	5 2	2 5	5 6	3 6
	Rhododendron 'Elizabeth'			
Percent of cuttings rooted	95	95	100	93
Average root ball diameter (cm)	5 1	5.6	5 0	5 1

[1] 40 cuttings per treatment

Table 4. Effects of CO_2 mist and supplementary lighting with high pressure sodium (HPS) lamps on rooting of *Juniperus*[1]

	− CO_2		+ CO_2	
	− HPS	+ HPS	− HPS	+ HPS
	Juniperus squamata 'Meyeri'			
Percent of cuttings rooted	65	48	80	50
Average number of roots per cutting	4 4	3 2	6 9	5 0
Average root length per cutting (cm)	21 7	14 3	30.9	18 8
	Juniperus sabina 'Skandia'			
Percent of cuttings rooted	43	28	63	48
Average number of roots per cutting	1 6	0 8	6 4	3 1
Average root length per cutting (cm)	5 2	1.8	27 5	15 2

[1] 40 cuttings per treatment

Among 10 genotypes tested, rooting of two were promoted, five were not affected and three were inhibited by HPS. No general effects of light on rooting could be observed. This is in agreement with the results of many other investigators (1, 13, 18). High intensity lighting during the propagation of woody cuttings has not been widely investigated, but it has increased rooting of herbaceous cuttings (3).

The mechanism of root initiation is not fully understood and rooting response of cuttings is determined by a complex interplay of internal and environmental factors (7). The role of carbohydrates in rooting has been investigated (5, 12) and a proper balance between sugars and auxins for optimal production of

adventitious roots has been demonstrated (15, 16). Both CO_2 and HPS lighting are related to photosynthesis. CO_2 enrichment has increased photosynthesis (8). Photosynthetic activity of 22 species has been increased by HPS lighting (4). Inhibition of rooting by CO_2 mist and HPS is probably due to above optimal levels of carbohydrates (6), high foliar temperatures (2), or excessive dehydration (12). At the present, CO_2 mist offers an inexpensive and safe aid in rooting cuttings, while the value of HPS lighting in propagating woody cuttings is not so apparent

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MODERATOR GARTH HOKANSON: Let us have some good questions now for our speakers. Please give your name and use the microphone.

BRUCE MACDONALD: Chet Boddy, have you had any experience with leaf-bud cuttings of some of the more vigorous forms of mahonias?

CHET BODDY: I have experimented with a few. In the spring I read a paper that was published in *The Plant Propagator* and I thought I would try that. They rooted. Leaf-bud cuttings do root. The paper I read that gave me the idea was written by someone who had only one plant that he didn't want to destroy. I think if you have a big stock field and you are in commercial production the best thing is to go ahead and take tip cuttings — if you have the wood. They produce a better plant. But yes, those smaller leaf-bud cuttings will root. Not as well, but they will.

BRUCE BRIGGS: In using spores for fern propagation, you mentioned 5% Clorox for sterilization. How is this prepared?

BRUCE LANE: The way we fix our solution is to take the Clorox from the store and use 5% of that plus 95% water or one part Clorox to 19 parts water.

HUDSON HARTMANN: I would like to ask Dr. Lin if he ran a statistical analysis of his data and how many replicate cuttings he used?

W. C. LIN: On the second experiment, we used 5 cuttings of each replicate with 8 replicates so that would be 40 cuttings altogether. We have run the statistical analysis but we didn't have enough time to put it on the slides.

RALPH SHUGERT. Rick, If I understand right you are lifting your potted *Magnolia grandiflora* understocks in late October or early November.

RICK WELLS: Yes, and some of the cuttings originated at that same time. As the girls prepare the understock by removing the side growth, some of the cuttings are made at that time. Those then would be rooted and potted on the following June to August. Then they would be ready a year from that fall. So it is two years from the time we stick the cuttings to the time the understock is ready to graft.

RALPH SHUGERT: If I have my notes right, then, it takes

3½ years from the graft to the finished 5 gallon cans.

RICK WELLS: Correct.

RALPH SHUGERT: So we are now 5½ years from the time you stuck the cuttings which are going to be the understock to produce the grafts.

RICK WELLS: Correct

BILL CURTIS: Why do you graft your *Magnolia grandiflora* cultivars instead of rooting them as cuttings?

RICK WELLS: We have done some experimenting with rooting; however, the percentages have not been such that it is economical at this time. By grafting, we always get in the area of 80%. It just seems more economical to us right now to graft. Most of the cutting experiments that we have done have resulted in rooting percentages more like 30%.

BILL CURTIS: What time do you put in your cuttings for rooting?

RICK WELLS: They do best when started in winter, although we have tried them at all different times.

BILL CURTIS: Late in the winter?

RICK WELLS: No, more in the fall?

BILL CURTIS: I have grown *Magnolia grandiflora* cuttings for 30 years and there are many years that I have 90% to 100% rooting. We use a heel cutting taken from two-year-old plants. There is no problem with them; sometimes they root so heavily that we have to put them in two-gallon cans.

RICK WELLS: Do you have a secret?

BILL CURTIS: Our cuttings are about 4 or 5 inches long. Also we take all our cuttings from two-year-old plants. We use a high rooting temperature, 80°F. We use Hormodin No. 3 and we wound real heavy on the side. I think it is just a waste of time to graft them on seedlings because you get a good root system by cuttings. I know some people say that cuttings don't produce a good root system, so that is why they use a seedling — it has a better root system. But we had a bad wind storm several years ago that blew over timber but we never lost a magnolia tree in the field. So rooted cuttings do make a good root system. I cannot see why you waste your time grafting magnolias when the cuttings will root so easily.

RICK WELLS: I don't think I will try to respond to that.

JIM SAHLSTROM: I will go along with Bill; we will be glad to grow some of your native plants for you in Oregon.

VOICE: Dr. Lin, how old are the stock plants you used in rooting Douglas-fir? The general experience that we have had is

that trying to root cuttings from older Douglas fir is not very successful. Juvenile Douglas-fir, we had no problem at all. I am curious to know how old the plants were?

W.C. LIN: That is a good question; I don't know. The trees are about 6 to 8 feet tall. We took cuttings right from the middle portion, or the middle portion to the top. So that is all I can answer you, I am sorry I cannot say how old the stock trees are.

VOICE: I have another question for you. I noticed on your slides that the roots systems under your added CO_2 experiments were rather one-sided. In forest nurseries that are trying to produce seed orchard stock, it is really a problem. Nurserymen don't want to grow one-sided root systems. I wonder if you have had any other experience with them where you have obtained a more radially symmetric system?

W.C. LIN: We propagate just like any other ornamental plant. The flats are just about 3 inches deep. In order to sustain the cuttings, which are about 4 to 6 inches tall, we obviously have to set them deep, almost touching the bottom of the flat. When that happens, then the roots normally just grow in one direction in most cases. I don't know if that answers your question or not.

VOICE: I have a question for Dr. Lin. What material is the CO_2 chamber made of, and what is the purpose of the high pressure sodium lamp; is the reason being that naturally you have low sunlight in Vancouver Island, B.C. area?

W.C. LIN: When we grow our liners, we can increase plant growth by using 16 hours per day of high intensity lighting. Just like we did on the propagation. We feel the natural light in our area is too low for plants to function properly. The second clue is when we have the CO_2 as a raw material for the plant to utilize, to synthesize carbohydrates, we normally expect to have strong effectiveness of the light. If we just increase the raw material (CO_2), but don't provide the light energy for photosynthesis, we will not benefit from the added CO_2. Also the high pressure sodium lamp would provide some long-day effects. We combine those two together. Therefore we use 16 hours lighting per day.

GARTH HOKANSON: What is the chamber made of? Plastic or welded iron?

W.C. LIN: It is home-made. I couldn't remember the name of the material very quickly. Could be polyethylene or polyvinyl chloride (PVC).

VOICE: I wonder if Dr. Lin has done any work with the manipulation of his stock plants by extending the photoperiod and enriching the atmosphere and if that has had an effect on the rootability of the plants, or if you feel that is an area of

investigation for the future?

W C. LIN: We considered that, yes. We thought about that but due to our limitations we have only gone to the propagation stage and the stage of early growth of the container plants.

VOICE: Why do you use CO_2 in this case? What are you trying to achieve? Are you targeting for the carbohydrate content or are you targeting for the acidity of the water?

W.C. LIN: Our primary purpose is to increase the carbohydrate level. Because, many, many studies have shown there is a proper balance between auxins and carbohydrates which is essential for rooting. We feel after many months in the propagation stage under low light, the carbohydrates are obviously going to be depleted rather than increases. That is why we are using the CO_2. Hopefully we can maintain the carbohydrates in this way.

WESTERN REGION 1980 AWARD OF MERIT

Presented by Steve Fazio

The recipient of the Western Region's 1980 Award of Merit received his B.S. degree from the University of California in 1940 and a Ph.D. in Genetics from the same institution in 1952.

His professional career started as a plant breeder for the Grant Merrill Orchards, Red Bluff, California, shortly after he attained the Ph.D. degree. He was involved with this organization in the breeding of new peach and nectarine cultivars.

After 3 years of this work he returned to the University of California in 1953 where he became a staff member in the Department of Viticulture and Enology. In his early studies he was involved in virus problems with grapes, working with plant pathologists at the University of California. He soon became interested in the propagation of grapes and conducted many studies dealing with propagation by cuttings, budding, and grafting and in studying grape rootstocks. He also worked with his colleagues in the Department of Viticulture and Enology on the evaluation of wine grape cultivars in California.

In 1974, he was invited to visit the grape growing regions of Germany and France to study grape propagation as practiced in those countries.

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Our candidate has been a strong and active supporter of the IPPS Western Region from its inception, serving as the Secretary-Treasurer almost from its inception. Dr. Curtis Alley has served the Society faithfully and well for many years and richly deserves the 1980 Western Region Award of Merit

SALT TOLERANCE OF ORNAMENTALS

CONRAD A SKIMINA

Monrovia Nursery Co.
Azusa, California 91703

Abstract. Three series of tests were conducted from 1977 through 1979 on a number of container ornamentals to determine their tolerance to salt fortified irrigation water at four different levels of salinity, 140, 300, 600 and 1200 mhos $\times 10^{-5}$ electrical conductivity (E C.) Plants were evaluated after at least five months of irrigation for their salt tolerance determined by <50% retardation, no mortality and no visual foliar burn Of the 118 cultivars tested, 29 were very tolerant, 38 were moderately tolerant, 43 were sensitive, and 8 were very sensitive

Data on the salinity tolerance of plants is becoming increasingly more important with the increased use or re-use of water and with the increased pumping of underground water causing intrusion of sea water into some aquifers (1,4,5).

Studies have been conducted by some with chlorides and sulfates only, others alternated with fertilizer salts, and some used a base nutrient + other salts. This study used either all fertilizer salt or ½ fertilizer + ½ sodium chloride (2,3,4).

The following reasons prompted us to conduct several series of experiments to screen the salt tolerance of ornamentals: 1) increasing inquiries by our customers for salt tolerant plants or information, 2) our embarking on a total water recycling system, and 3) the need for more information on salt stress of plants for trouble-shooting

MATERIALS AND METHODS

A series of tests were begun in 1977 and continued through 1979 to establish the salt tolerance of many container ornamen-

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MATERIALS AND METHODS

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tals. Four one-gallon plants of each cultivar or species for each of four treatments were permitted to establish for thirty days before commencing the treatments with salt-fortified irrigation water. All plants were hand irrigated. The test involved growing each set of four plants at four salinity levels of irrigation water; 140, 300, 600 and 1200 mhos $\times 10^{-5}$ E.C. The salts used for fortification of the water were:

1. 140 E.C. = all fertilizer salts (K_2SO_4 + NH_4NO_3) (2.7 N:1K)
2. 300 E.C. = ½ fertilizer salt + ½ sodium chloride
3. 600 E.C. = ½ fertilizer salt + ½ sodium chloride
4. 1200 E.C. = ½ fertilizer salt + ½ sodium chloride

Fertilizer salts were used for one-half of the source of salt because in some cases, problems associated with salt injury were caused by overfertilization or by poor irrigation practices by some nurserymen in conjunction with their feeding program. The source of almost all of the K and N was the water; all of the remainder of the elements were added to the soil mix consisting basically of ⅔ redwood sawdust + ⅓ loam soil.

Classification of plants for their salt tolerance was based on not more than 50% reduction in growth associated with no visual leaf burn and of negligible mortality, if any. Interpolation was used for classification of the plant, if the tolerable salt level appeared to fall between two test levels. For example, *Bougainvillea* 'Barbara Karst' was classified to tolerate up to 1000 E.C. water even though it survived 1200 E.C. with no visual foliar burn, because at 1200 E.C. there was more than 50% reduction in growth.

RESULTS

Typical evaluations were made as follows:

Plant	Water E.C.	Percent Relative Growth	Percent Dead	Comments
Arbutus unedo	140	100	0	no burn
'Compacta'	300	80	0	no burn
(sensitive)	600	40	75	defoliation
	1200	0	100	defoliation
Bougainvillea	140	90	0	no burn
'Barbara Karst'	300	100	0	no burn
(tolerant)	600	75	0	no burn
	1200	45	0	no burn

A summary of the evaluations in the above manner are compiled in a condense manner in Tables 1, 2, 3, and 4. It should be kept in mind that the tolerances are listed on the basis of the salinity of the water, not of the soil. Soil salinity based on the saturated extract method usually indicated higher salinities than the water; in some cases two to three times higher. It must be kept in mind also that the salt tolerance might be influenced by

the season. In Southern California, plants in tests conducted during the winter months will show more tolerance to higher salinity water because of the associated cool weather and added leaching from rains reducing the soil salinity level. By contrast, summer tests will show less tolerance.

Table 1. Plants exhibiting very high tolerance to salts

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Araucaria heterophylla	1000	83	0
Asparagus densiflorus 'Sprengeri'	1000	85	0
Bougainvillea 'Barbara Karst'	1000	55	0
B × buttiana 'Orange King'	1200	70	0
B 'Camarillo Fiesta'	1100	55	0
Callistemon citrinus	1000	67	0
× *Cupressocyparis leylandii*	1200	78	0
Cordyline indivisa	1200	80	0
Dietes vegeta (Syn *D iridioides*)	1200+	100	0
Festuca ovina var *glauca*	1200	60	0
Ficus microcarpa var Nitida (Syn *F nitida* Hort)	1000	70	0
Hibiscus rosa-sinensis 'Brilliant'	1000	70	0
H rosa-sinensis 'President'	1200	70	0
Juniperus chinensis 'Robusta Green'	1200	60	0
J chinensis 'Kaizuka' (Syn 'Torulosa')	1200	70	0
Platycladus orientalis aureus nanus	1200	85	0
Spartium junceum	1200	90	0
Yucca aloifolia	1200	50	0

[1] mhos × 10^{-5} electrical conductivity

Monrovia Nursery uses the low salinity San Gabriel River as their source of irrigation water and for their make-up water in their water recycling facility. In contrast, Colorado River water has a conductivity of approximately 100 mhos × 10^{-5} or 2.5 times the salt level of San Gabriel water. Consequently, if water is fortified at a suitable fertilizer salt conductivity level for salt sensitive plants, the Colorado River water would have only 41% of the useful fertilizer salt compared with that of San Gabriel River water at the same conductivity. Salt sensitive plants can be grown with poorer quality water such as that from the Colorado River; however it would be a considerably slower process and careful consideration has to be given to the type of medium and irrigation practice.

Table 2. Plants exhibiting moderate tolerance to salinity

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Agapanthus umbellatus (*A. africanus* or *A. orientalis*)	500	73	0[2]
Arecastrum romanzoffianum	500	83	0
Asparagus densiflorus (*A. sarmentosus* of Hort.)	600	100	0
Brahea edulis	600	100	25
Brunfelsia pauciflora var. *calycina*	400	73	0
Buxus microphylla var. *japonica*	500	62	0
Crassula ovata	600	75	0
Cupressus arizonica	400	59	0
Cupressus sempervirens 'Glauca'	400	100	0
Dodonea viscosa 'Purpurea'	600	70	0
Euonymus japonica 'Grandifolia'	600	90	0
Hibiscus rosa-sinensis 'Ross Estey'	800	82	25
Juniperus chinensis 'Pfitzerana'	600	50	0
Ligustrum japonicum	400	85	0
Nerium oleander 'Cherry Ripe'	600	80	0
Ophiopogon jaburan	600	100	0
Philodendron selloum	500	87	0
Pinus thunbergiana	400	100	0
Rhaphiolepis indica 'Enchantress'	500	90	0
Syzygium paniculatum	500	82	0

[1] mhos $\times 10^{-5}$ electrical conductivity
[2] Interpolated as no mortality; 25% mortality at 600 mhos $\times 10^{-5}$

Table 3. Plants exhibiting sensitivity to salinity

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Arbutus unedo 'Compacta'	300	80	0
Abelia × *grandiflora*	300	80	0
Berberis × *mentorensis*	300	85	0
Cedrus deodara	300	85	0
Ceratonia siliqua	300	100	0
Cinnamomum camphora	300	90	25
Clivia miniata 'French Hybrid'	300	80	0
Euonymus japonica 'Silver King'	300	100	0
Ficus benjamina	300	90	0

Table 3. Plants exhibiting sensitivity to salinity (cont'd)

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Forsythia × *intermedia* 'Spring Glory'	300	100	0
Gelsemium sempervirens	300	100	0
Ilex × *altaclarensis* 'Wilsonii'	300	85	0
Lantana 'Confetti'	300	80	0
Magnolia grandiflora	300	80	0
Nandina domestica	300	70	0
Ophiopogon japonicus	300	80	0
Pyracantha koidzumii 'Victory'	300	80	0
Podocarpus macrophyllus var *maki*	300	85	0
Washingtonia robusta	300	100	0
Yucca filamentosa	300	80	0

[1] mhos × 10^{-5} electrical conductivity

Table 4. Plants exhibiting extreme sensitivity to salinity

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Acanthus mollis 'Oak Leaf'	200	81	20[2]
Cytisus × *praecox* 'Moonlight'	250	60	0
Cedrus atlantica	200	80	30[2]
Ilex cornuta 'Dazzler'	200	68	20[2]
Mahonia aquifolium 'Compacta'	180	75	45[2]
Ensete ventricosum	250	66	0
Pittosporum tobira 'Variegata'	250	79	0
Phormium tenax 'Atropurpureum'	200	62	40[2]

[1] mhos × 10^{-5} electrical conductivity

[2] Interpolated; based on normal increase in soil salinity to 2× the conductivity of the irrigation water With proper selection of medium and leaching practice, this mortality could be reduced substantially

DISCUSSION

It was evident during the course of the tests, that those treatments receiving the higher salinity water had lower water penetration and percolation rates, indicative of sodium-saturated dispersed soil colloids.

Many plants would probably have suffered more if the salts were derived solely from NaCl. There is competitive uptake of the nutrient salts, if these are present, reducing the sodium uptake and also aiding in plant growth or retention of color.

Because excess ammonium N was present in the higher salt levels, there was a reduction in soil pH. Many of the soil samples taken from the higher salt levels had pHs ranging from 4.0 to 4.9, whereas those receiving lower levels had pHs in the 5.1 to 5.7 range.

CONCLUSIONS

1 Nutrients given at high levels help a plant tolerate high salinities better.

2. Soil salinities build up to much higher salt levels than the salinity of the irrigation water, by 2 to 3 times more.

3. High sodium levels disperse soil colloids reducing percolation and aeration.

4. High fertilizer salt levels, especially those derived from ammonium sources, reduce soil pH. Consequently, the effects on the plants may be the result of other causes in addition to the salt levels.

5. Slow overhead irrigation for several hours reduces the salinity build-up of the soil because the residence time of the water in the soil is greater. In contrast, hand watering usually builds up the salinity of the soil even if the cans are flooded and receive the *same* quantity of water.

6. Calcium reduces salt injury by:
   a) helping aggregate colloids in the soil, thereby increasing leachability.
   b) displacing sodium.

7. Abnormal levels of certain elements, such as boron, may aggravate a salinity problem.

8. Coarse soil mixes build up less salinity because they leach easily.

9. High salt levels induce some plants to flower.

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EFFECT OF LATERAL WOUNDING IN GROWTH-REGULATOR-TREATED ARCTOSTAPHYLOS CUTTINGS

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Abstract. In a comparative study of laterally wounded and non-wounded cuttings of three species of *Arctostaphylos* Adans (Ericaceae) under mist house conditions, it has been found that in two hairy species, *A andersonii* Gray and *A tomentosa* (Pursh) Lindl *var tomentosiformis* (Adams) Munz, lateral wounding increases root formation to a very high degree This is less so in *A manzanita* Parry

Normally true species are propagated by seeds. However, it is a well known fact that many of the species of *Arctostaphylos*, when propagated by seed, behave in an erratic fashion. It appears desirable then, to propagate them vegetatively. The majority of *Arctostaphylos*, species and cultivars alike, do not have any rooting problems when propagated by cuttings. There are, however a few species, notably the hairy ones and some of the larger upright species, which seem to require special treatment.

MATERIALS AND METHODS

As with most other evergreens, the cuttings should be at the "semi-hard" stage of development, a stage in Southern California usually reached by August/September. *Arctostaphylos andersonii* Gray, *A. manzanita* Parry, and *A. tomentosa* (Pursh.) Lindl. *var. tomentosiformis* (Adams) Munz, which responded poorly to previous efforts to root them in a conventional manner were chosen for the trial. On August 16, 1979 semi-hard tips 7 to 10 cm in length were cut in the usual way; half of the cuttings were laterally wounded from the base up for about 1 cm. They were then divided into equal parts and dipped into commercially available rooting powders and set into clay trays in a medium consisting of half vermiculite and half perlite. They were placed into the mist house with intermittent mist of 6 sec. every 12 min. The bench was heated by electrical cables to 25°C (77°F).

A. andersonii and *A. manzanita* were lifted on October 16, but *A tomentosa var. tomentosiformis* remained on the bench until November 27. The rooted cuttings were classified and divided into four categories according to the quality of the roots:

vg = very good; 6 (or more) primary roots emerging from the cutting
g = good: 4 to 5 primary roots emerging from the cutting
f = fair: 2 to 3 primary roots emerging from the cutting
p = poor: 1 primary roots emerging from the cutting

The length of the roots was not recorded, but varied greatly. The majority of the primary roots showed, additionally, a fair

number of secondary and smaller roots.

RESULTS AND DISCUSSION

In the hairy species, *A. andersonii* and *A. tomentosa var. tomentosiformis*, the difference in rooting between laterally wounded and conventional cuttings is striking, less so in *A. manzanita*. In the case of *A. manzanita*, where a larger spectrum of rooting hormone could be explored, a marked decline in the percentage of cuttings rooted can be observed, when the level of IBA concentration is greater than 1 percent.

Since the number of cuttings involved in this trial was too small for proper statistical evaluation, the figures may not be conclusive, but nevertheless are indicative enough to show a trend. It appears that the lateral wounding of otherwise difficult-to-root species in the genus *Arctostaphylos* is beneficial.

Table 1. The effect of type of hormone and lateral wounding on rooting percentage and root quality of *Arctostaphylos* cuttings

Hormone	Type of cuttings	Percent rooted	Root quality (see above)			
Arctostaphylos andersonii						
Rootone F	not wounded	0				
Rootone F	wounded	100	2vg	5g	3f	
Hormodin 2	not wounded	10			1f	
Hormodin 2	wounded	100	8vg	1g	1f	
Hormex 8	not wounded	0				
Hormex 8	wounded	90	6vg	3g		
Arctostaphylos manzanita						
Rootone F	not wounded	90			3f	6p
Rootone F	wounded	80	4vg	4g		
Hormodin 2	not wounded	10				1p
Hormodin 2	wounded	70			2f	5p
Hormex 8	not wounded	40			2f	2p
Hormex 8	wounded	60		3g	1f	2p
Hormex 16	not wounded	30				3p
Hormex 16	wounded	40	1vg			3p
Arctostaphylos tomentosa var tomentosiformis						
Rootone F	not wounded	10				1p
Rootone F	wounded	60	1vg	3g	1f	1p
Hormodin 2	not wounded	0				
Hormodin 2	wounded	60	1vg	2g	1f	2p

[1] 10 cuttings per treatment

NATURE AND MANAGEMENT OF CANKER PATHOGENS INFECTING CUTTINGS

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Most fungi which cause canker diseases are weak pathogens and cannot infect undamaged tissue. They must have a wound for effective penetration of the plant. The wound at the base of a cutting or at a graft presents a fine infection court for these fungi, and not surprisingly, several canker diseases appear frequently under conditions of commercial propagation. General symptoms of canker diseases, when they occur on above-ground plant parts, are death of the cambium and overlying bark, and discoloration of the wood below from its usual greenish-white color to a black or brown. On small plants the cankers usually girdle rapidly and spread above and below the point of infection, resulting in death of branches beyond the canker even where no pathogen can be found. If the branch is not killed quickly, a depressed area develops which may or may not have a raised callus edge. The pathogens produce fruiting bodies within which spores are found in the bark over the canker. These fruiting bodies are the usual source of inoculum for reinfection and are of major importance in diagnosis.

When infection occurs on cutting wounds, the canker may be entirely below ground or may spread some distance above ground. The result is killing of the entire plant. In some cases the infected cutting is not killed quickly but may survive one or two years before succumbing. The symptoms of such infected cuttings superficially resemble *Pytophthora* root and collar rot diseases, but control measures for *Phytophtora* diseases are not appropriate for the canker diseases. Control of canker diseases in propagation involves use of pasteurized or pathogen-free rooting media and a fungicide dip for cuttings or scions.

The following is a discussion of three diseases this worker has observed causing appreciable losses in Southern California nurseries. Nursery blight of junipers, caused by *Phomopsis juniperovora*, is a very common disease on many juniper cultivars outside of California. Under local conditions, I have only seen the disease on *Juniperus virginiana*, the red cedar. On this plant the disease first causes yellowing and browning of the foliage of liners and plants in gallon containers, frequently with death of the entire plant. Cankers may be seen on the main stem. Typical fruiting bodies are inconspicuous pycnidia resembling bumps on the bark. Because the red cedars were grown for grafting root-

stocks, the disease became important by causing a shortage of stock plants. A persistant problem of low graft success was also undoubtedly due in part to infection of graft wounds by this pathogen. The problem was solved by replacing the red cedar with a much less susceptible but also less convenient species for rootstocks.

Phomopsis canker of gardenia, caused by *Phomopsis gardeniae*, results in a corky swelling at and above the soil line and a yellow-orange discoloration of the wood under the canker. Although the infection typically occurs at the base of the cutting under nursery conditions, some infected plants survive even into 5-gallon size before dying. Obviously many doomed plants are sold in apparently healthy condition.

Camellia canker, caused by *Glomerella cingulata*, results in great losses at some nurseries in certain cultivars; mortality of 50 percent or more in liners and young plants in gallon containers has been observed. When the plant is infected as a cutting, a reddish-brown discoloration extends under the bark from the base of the plant to varying distances above the ground. This phase of the disease is often confused with *Phytophthora* root rot caused by *P. cinnamomi* and others. It is necessary to distinguish the two diseases because different control measures are required for each. It is interesting to note that some nurseries have attempted and, not suprisingly, failed to control the canker disease using drenches of fungicides with activity only against the Phycomycetes, of which *Phytophthora* is a member. Most camellia cultivars grown in California seem to be resistant but some appear to be especially susceptible. These include Daikagura, Pink Parade, Leonard Messel, Jordan's Pride, Snow White, Pearl Maxwell, Kumasaka and Magnoliaflora. This list is not complete, and is based only on casual observations.

Jeff Dodson, a graduate student of Cal Poly, and this author have investigated some of the conditions necessary for infection of camellias by *G. cingulata*, hoping to learn how to better apply measures to control the disease. We looked at the above-ground phase, rather than the cutting phase since it is much easier to work with rooted plants than cuttings. Factors we looked at were: 1) the need for high humidity during infection, 2) the effect of temperature on infection, and 3) the length of time that wounds remained susceptible.

Young plants were wounded by removing a petiole and inoculated using a suspension of spores applied with a cotton swab. Eventually infected plants wilted above the point of inoculation and the leaves died.

Temperatures between 18° and 28°C (64° and 82°F) had no effect on disease incidence even though 23°C (73°F) is consid-

ered the optimum for the fungus. No difference was found in infection rate in plants incubated at less than 40% relative humidity, or in a saturated atmosphere in a plastic bag. Wounds made by breaking petioles become essentially non-susceptible after only 36 hours, again with no influence of temperature.

From these results it is concluded that relative humidity or available free water is not an important factor in infection of cut stems, and that any fungicide active against *G. cingulata* would provide sufficient protection for the brief period that wounds are susceptible to infection.

APPROACHES TO PLANT PROPAGATORS' INTEGRATED PEST MANAGEMENT

PAT MORISHITA

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Lately one only has to pick up the trade journals and find articles discussing integrated pest management (IPM) in the ornamentals industry. Scientists have many interpretations of IPM; it is described as a philosophy, discipline, system, or program. The researchers in agricultural endeavors welcome this as it elevates pest control to a more professional and technological level. The environmentalists look upon it as reducing or eliminating the use of pesticides. The legislators like it as everybody discusses and seems to like it and nobody is vigorously opposed to it. However, when everything has been said and outlined the growers are the people who must decide whether they want it or not. I would like to discuss some of these ideas as I see how and where they would fit into your industry. Every facet of the industry, beginning with the propagators to growers and even the retailers are actually using some of the principles of integrated pest management. First of all, let me give a definition of it by the National Research Council that you can understand. The Council stated, "It is a system of pest control that utilizes all suitable techniques in a compatible way to reduce pest populations and maintain them below the economic injury level."

Let me break this ". . . all suitable techniques in a compatible way to reduce pest populations and maintain them below the economic injury level" down to several categories: (1) Chemical Control, (2) Cultural Practices, (3) Preventive Measures, (4) Host-Plant Resistance, and (5) Biological Control.

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CHEMICAL CONTROL

Chemical control of pests (insects, mites, fungi, bacteria, viruses, or weeds) has been the first choice because of its availability for immediate use, ease of application, and quick adequate results. During the past few years the use of pesticides as the primary means of pest control has become less than satisfactory. Pests have shown increasing signs of resistance and/or tolerance to pesticides. Cost for pesticides has risen dramatically over the past few years. Government rules and regulations controlling registrations of new materials, application methods (OSHA regulations on safety during applications) have increased substantially. In particular, methods to protect the environment such as Environmental Impact Reports covering everything from the water we drink and the food we eat to the air we breathe have received the greatest emphasis. Let me give you some examples of the above. There is a situation in the propagation of chrysanthemum cuttings where today, in California, we do not have a commercially legal material that will control the leafminer. Every chemical that we have tested (commercially available and experimental compounds) has shown little or no success on year-'round chrysanthemum potted and cut flowers. The primary source of this leafminer is from rooted cuttings purchased from other states. Flower growers obtaining these infested cuttings have suffered tremendous losses, some have lost as much as 75% or more of their crops.

Last month I was invited to attend a meeting sponsored by the Society of American Florists (SAF) in Florida. The Growers Council of SAF invited entomologists from various state universities working on this particular pest. I discovered that this problem was worldwide and other flower-producing nations are gravely concerned. This is a case where the problem originated with the propagator and continued to the grower. No concrete answers were found at this meeting but all the problem areas were identified and discussed. Considerable basic and applied research must be completed in order to find adequate solutions to the leafminer problem on chrysanthemum.

CULTURAL PRACTICES

The University of California has advocated over the years that good insect control begins with clean cultural practices. This is not to say that clean cultural practices will completely eliminate plant pests but they will help trememdously when the need for pesticides occurs. Here is an outline of the cultural practices that would enhance an IPM program:

1. Weed control around the outside and inside of greenhouse (this is a good source of pests).

2. Algae control under and on the benches and/or around the beds (controls fungus flies).
3. Pasteurization (steam or chemical) of media (controls pathogens, nematodes, insect pupae).
4. Clean and healthy stock plants in mother blocks (prevents the start of disease and insect infestations).
5. Precise fertilization and watering (lessens plant stress; obvious advantages).
6. Discarding of all weak, damaged or dead plants (potential source of disease and insects).
7. Spacing of plants for air circulation and light penetration (makes for healthier plants).

One cultural control practice that is often overlooked is the physical structure of the greenhouses. It may seem trivial to patch or replace torn plastic sheetings or replace a glass pane, but these are the main points of entry for many types of pests. If you can keep one insect out of the greenhouse, that is one pest that will not have to be controlled. It is very important to cover every hole or opening at the base of the greenhouse as these are the points of entry for flying insects. One grower in the Encinitas, California, area was able to cut down the worm damage to carnations by covering the base boards with dirt and by utilizing plastic screening on the sides of the houses

Several years ago, one propagator was having trouble controlling tortrix in his trays of azalea cuttings. Since he was misting the cuttings during the day, there was no way that he could spray during the day and it was simply not economical for him to treat at night. A system was devised to apply the pesticide in combination with the last misting of the day by injecting the pesticide into the mist system The mist nozzles were replaced with ones that had lowered gallonage output and produced finer particles which effectively controlled the tortrix. In addition, by utilizing less water he was able to cut down on the dying-back of his cuttings

Several of the growers are now using hydrated lime on the greenhouse floor to control algae and weeds which, in turn, will control the fungus flies by removing their primary breeding site. With lime on the floor, the greenhouses have a very clean appearance. Some growers are also experimenting with copper sulfate to control algae and this material appears to hold considerable promise.

In the late 1960s, many growers were using wood shavings as the base for flats and pots. However, it was subsequently discovered that many of the disease and soil-infesting insect problems originated from this practice. The problem began when the me-

dia started to break down. Initially, it was thought that arthropods were the cause of the breakdown, but it was discovered that heavy fertilization of the cuttings and plants was the real culprit.

PREVENTIVE MEASURES

There are many day-to-day local problems but we face another grave situation. As growers import seeds and plants from foreign countries, the control of exotic pest species that come in with these products becomes a potentially serious problem. Quarantine, eradication, and transport programs play a very important role in IPM by detecting and eliminating problems before they get a foothold. Quarantine inspections and programs are definitely important and nursery inspections in California aid considerably in the efforts of all involved in pest control. However, these rules should not be inflexible. They should be subject to modifications based on the particular commodity and grower's needs. I am currently involved in updating an obsolete system which has been in operation for many years so that it can accommodate the needs of the young bromeliad industry in California. The current practice is to fumigate a shipment of bromeliads with methyl bromide when insects are found on the plants. The source of these plants is South America and the need to control insect pests on the plants before they are brought into California is obvious. Unfortunately, methyl bromide kills 30 to 50% of the bromeliads and this is of great concern to the industry. I am already looking at other chemical materials to control the incoming pests which will be less harmful to the plants.

HOST-PLANT RESISTANCE

Host-plant resistance is always included in an IPM scheme but in the ornamentals industry this will not be easy. With *thousands of species of plants, I believe the responsibility for this* type of work should be assumed by the basic producers of plants. Most propagators do not have the time to research the background information necessary to develop this type of program. Also the time and money involved would be tremendous.

BIOLOGICAL CONTROL

Biological control [defined as "controlling arthropods (insects and mites) or pathogens (fungi, bacteria, etc.) with other beneficial arthropods and biological agents"] as a part of an IPM program has been incorporated into models at many institutions all over the world. In particular, biological control of mites and whiteflies with predators and parasites has received the greatest attention. However, IPM is generally crop-specific, as in the case of cotton, alfalfa, corn, and others. In the ornamentals industry a majority of the plants are grown together and each species has its

complex of pests.

With several pests being present at any one time, the control of the other pests present will necessitate the use of chemicals. For example, effective control of mites with predators and without pesticides may allow other pests, such as aphids and worms, to develop to the point where chemicals are needed to control them. These chemicals, in turn, will destroy the beneficial mite predators unless careful attention is given to their selection and proper timing of application. In general, it is more difficult to develop a successful biocontrol program on a crop such as ornamentals with such a diverse complex of pests.

The predators and parasites will not control 100% of the pest population as there must be a small population of pest present to maintain these beneficials.

Utilization of parasites and predators for control of pests is slow when compared to pesticides. Materials such as *Bacillus thuringiensis* do not kill quickly and there will be a great amount of damage before the materials start to take effect.

To establish a good biological control program, a qualified person knowledgable in the priniciples of biological control must be contracted to initiate the program. If a grower commits himself to the principle and starts on the project, he must follow through with the entire program. He should expect that it may take some time before any results are observed.

IPM is an all-inclusive approach to pest control and at the present time I do not believe that with the resources we have the industry can accept the concept wholly. However, there are many features in the concept the grower can take and put to good use.

PROPAGATION OF GIANT SEQUOIA BY ROOTING CUTTINGS

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Several years ago, in a paper on the advantages of reforestation with vegetatively propagated trees, Bill Libby wrote: "The genetic leverage available with vegetative propagation makes reforestation using rooted cuttings . . . (an) attractive new management technique . . .". Since that time, the use of vegetative propagation in forestry has increased, and several countries, including

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Canada, Finland, and West Germany currently have large scale operations for rooting cuttings for reforestation. It is my contention that the same option is open to us with some of our local species, including the one I will discuss today — the giant sequoia (*Sequoiadendron giganteum* (Lindl.) Buch.)

Many people are familiar with this spectacular California endemic. It is grown widely in Europe and this country as an ornamental. The species is native in modern times only to the west slope of the Sierras, but we know that in earlier geologic periods its ancestors grew in Europe, Greenland, and Spitzbergen. Changing climates over geologic time appear to be associated with its migration and current restriction in range (1,2,4).

Several years ago, Rundel (6) found that moisture gradients dropped sharply beyond the boundaries of the Giant Forest population of giant sequoia. This finding may be a clue to the species' limited range, and one might speculate that it is limited summer moisture that discourages the establishment of new seedlings outside the geographic boundaries of extant populations. However, the success of many ornamental plantings, and many small forest plantings, leads one to believe that, once the problem of establishment is overcome, giant sequoias can survive and grow well in a wide range of climates and soils.

The rapid growth and substantial size of ornamental plantings of giant sequoia, while impressive, cannot be taken as representative of the real average growth potential that can be expected in a forest environment. However, measurements taken in 41 forest plantings in California and Oregon show that giant sequoia often performs as well as other competitor species and, in several plantations, surpasses the competitor species in height and/or diameter at breast height (3).

In addition, work at the University of California at Berkeley shows that juvenile giant sequoia is easily cloned via rooting cuttings (3,7), making giant sequoia an attractive experimental organism for genetic studies as well as a likely candidate for clonal forestry.

In this paper I will discuss three cloning experiments — a fertilizer experiment, an experiment with cutting technique, and a very small, but interesting, experiment with older giant sequoia material. The purpose of these experiments was to develop techniques that would promote giant sequoia cuttings to root with consistency and reliability.

MATERIALS AND METHODS

By 1975, Libby had developed a "standard rooting procedure" for radiata (Monterey) pine as follows: branch cuttings were trimmed (usually to 6 to 8 cm) and soaked in a Benlate

(benomyl) solution at 1.13 gm/gal of water for ½ hour. After removal from Benlate, a fresh basal cut was made, and the cuttings were dipped in a solution of indolebutyric acid (IBA) at 4000 ppm in 95% ethyl alcohol. The cuttings were then stuck in preformed depressions in the medium and placed on a mist bench where they received two morning mist sprays and three afternoon sprays, each of approximately 1-minute duration with 1 hour between them. Daylength was extended by incandescent lights to 16 hours; bench temperature was not controlled. Summer temperatures were modified somewhat by whitewashing the greenhouse in March or April, depending on the weather. The standard rooting medium consisted of equal parts of Canadian sphagnum peat, nitrogen-charged redwood sawdust, and oak leaf mold.

Fertilizer Experiment: In this experiment, 380 cuttings were set from 232 six-month-old seedings from many different populations. All of these seedlings were greenhouse-grown in Albany, California. Cuttings were stuck in Leach supercells (one cutting per cell), and systematically assigned to one of three treatment groups as follows: 147 received no fertilizer, 141 received Ortho Azalea Food (10N-8P-7K) at 1 tbs/gal, and 92 cuttings received Ortho Upstart (3N-10P-3K) at 4 oz/gal. Cuttings were fertilized weekly with sufficient fertilizer at each application on reach the lower end of the cuttings (2 to 3 cm into the rooting medium). The cuttings were sprayed with water after each fertilizer application to prevent damage to the foliage. Cuttings were considered rooted when the first root extended to the bottom of the container.

Results: Rooting results after 6 months are shown in Table 1. Controls rooted at 70%; Azalea-food treated cuttings rooted at 88%, and Upstart-treated cuttings rooted at 86%. Chi-square tests indicated highly significant differences among all treatments (P=.0002), but no significant difference between the Azalea and Upstart fertilizer treatments. Average numbers of primary roots initiated per rooted cutting are shown by treatment group in Table 2. The control group averaged 2.4; Azalea food-treated, 2.8; and the Upstart-treated, 3.6 roots per rooted cutting. Differences between treatment groups was significant (P=.006) (see ANOVA 1).

Table 1: Fertilizer Experiment. Rooting Percentage at 6 Months

Treatment	Rooting Proportion	Rooting Percentage
Control	103/147	70
Azalea Food	124/141	88
Upstart Fertilizer	79/92	86

Table 2: Fertilizer Experiment Average Number of Roots per Rooted Cutting after 6 Months

Treatment	Number of Roots Per Rooted Cutting
Control	2 4
Azalea Food	2 8
Upstart Fertilizer	3 6

ANOVA 1: Fertilizer Experiment Average Number of Roots per Rooted Cutting

Source	df	MS	F	P
Fertilizer	2	18 464	5 279	006
Residual	303	3 498		

Discussion: The results of this experiment are consistent with our other experiments carried out in the same environment Later experiments, however, in which the amount of water applied was substantially less than in the above-described experiment, do not support these findings, and suggest that under low-mist conditions, fertilizer treatments at these levels are detrimental (3).

Cutting Angle: In the summer of 1976, at the Asilomar meeting of the Western Region Plant Propagators' Society, I learned that the angle of the basal cut may influence the shape of the resulting root system. In September, 1976, I set up an experiment to test the influence of cutting angle with giant sequoia cuttings I used 203 cuttings from 36 clones from 14 population samples. Approximately half of the cuttings were cut at a 45° angle, while the others were cut at a 90° angle Cuttings were set in clear plastic containers (Pickering tubes). The medium in the lower ⅔ of the container consisted of equal parts of Canadian sphagnum peat, #2 sand, and redwood soil conditioner, plus 4.5 lb dolomite lime, 2.5 lb superphosphate, ¼ lb ammonium nitrate, and ¼ lb potassium nitrate per cubic yard of mix[1]. Cuttings were fertilized weekly with Upstart at 4 oz/gal of water.

Results· After 2 months, the angle-bottomed cuttings had rooted 47%, and the straight-cut ones had rooted 28%. After 3 months they had rooted at 84% and 76% respectively and, after 9 months, rooting percentages were 90 and 83, respectively, with both groups averaging 4.3 roots per rooted cutting.

Discussion: I did not find differences between treatments in the number of roots per rooted cutting. But, it appears that angled cutting may be associated with greater speed of rooting, and possibly higher rooting percentages This experiment was not replicated, and should be repeated. Angled cuts have now become part of the standard rooting procedure for giant sequoia.

[1] This mix was developed at the University of California at Davis

Rooting Older Cuttings: In October, 1975, I attempted to use the standard rooting technique on cuttings from several 40-year-old giant sequoias growing on Kimberley-Clark land in northern California. After 11 months on the mist bench, not a single cutting had rooted, but some appeared to be still alive, and had healthy white callus tissue at the base. I saved 30 of the best ones, dipped 15 of them in IBA at 4000 ppm for 5 seconds, and kept the other 15 as controls. All of the cuttings were reset on the mist bench. Callus tissue was not intentially damaged in the process, although both sets of cuttings were disturbed when they were removed from the medium

Results: After 10 additional weeks on the mist bench, 13 of the 15 IBA-treated cuttings had rooted, and only 2 of the control cuttings had rooted. All 15 rooted cuttings were transplanted and moved to a University of California greenhouse in Albany, where they were fertilized weekly with Azalea food at 1 tbs/gal of water. During transplanting, it was noted that the root systems were generally small and delicate, the tops dry and off-color. By May, only 2 of the plants were still alive.

Discussion: It appears that the second IBA treatment was associated with rooting in these older cuttings. The clear difference in rooting between the two groups indicates a real effect (87% compared with 13%), but the experiment was very small, and should be repeated on a larger scale.

Why most of the cuttings died after rooting and transplanting, remains a mystery; this is not the usual case with juvenile material. If the problem can be solved, it would open the way to propagate unusual mature adults for ornamental plantings, and would also make possible the use of mature individuals for seed orchards. This aspect of propagating giant sequoia is yet a challenge.

SUMMARY

The experiments presented here show that juvenile giant sequoia material can be clonally propagated with some ease by rooting cuttings. Rooting percentages under favorable conditions have been in the high 80's and 90's, and, in one experiment, rooting began after only 10 weeks on the mist bench. Mature material can be rooted with some difficulty. However, problems have been encountered in keeping this material alive after rooting has taken place.

Acknowledgements. This work was done at the University of California at Berkeley, and was supported by the U S D A Forest Service The author is indebted to Mark and Bunny Edwards and Judy Bendix for their assistance on these studies, and to Dr W J Libby for his guidance and suggestions

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DELETERIOUS METABOLIC AND MORPHOLOGICAL CHANGES RESULTING FROM SEED SOAKING PRIOR TO SOWING

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For many years growers have soaked seeds prior to sowing in the belief that germination will often be improved. However in many cases exactly the opposite effect is achieved; that is, germination will be reduced or seedling growth will be abnormal. A further reason to study soaking injury is highlighted by new changes in cultural practices. Recent work has focussed more attention on seed soaking prior to sowing as a means of improving field or greenhouse seedling emergence and uniformity. Two striking examples highlight this:

1. The use of pre-germination chambers to prepare materials for fluid drilling. This interesting technique is now used by growers of high value vegetable crops in many countries and is the result of recent research work at The National Vegetable Research Station in England (12). The method is also suitable for small scale use (7). It seems highly likely that this technique will prove useful for woody ornamental plants as well as other ornamentals. Indeed, equipment is now being developed for the bedding plant industry for this purpose.
2. The use of osmotic priming techniques for seeds. Using this method seeds are partially hydrated in a controlled manner.

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1. The use of pre-germination chambers to prepare materials for fluid drilling. This interesting technique is now used by growers of high value vegetable crops in many countries and is the result of recent research work at The National Vegetable Research Station in England (12). The method is also suitable for small scale use (7). It seems highly likely that this technique will prove useful for woody ornamental plants as well as other ornamentals. Indeed, equipment is now being developed for the bedding plant industry for this purpose.
2. The use of osmotic priming techniques for seeds. Using this method seeds are partially hydrated in a controlled manner.

The degree of hydration may be controlled by immersion of the seed in solutions of varying strength (i.e. determines available water.) A biologically inert solution is used with a high molecular weight to avoid entry of its molecules into the seed. It is possible to induce early germinative stages with no apparent external changes to the seed (except perhaps a slight change in size). This results in more rapid and even germination after treatment with no requirement for specialized equipment (2,3).

A literature search reveals that seed injury on soaking can occur (1,13), although very few practical recommendations have been given for pre-soaking seeds to maximize germination. This difficulty is due to the fact that species, cultivars and even seed lots may vary in their response to injury after soaking. In order to quantify some of these effects I have conducted a series of experiments on soaking injury in seeds of a number of genera.

Evidence for soaking injury In a recent series of experiments metabolic injury of seeds has been studied after soaking (5,6,8,9,10). Seeds sensitive to injury demonstrate rapid alcohol fermentation and a gradual depletion of seed reserves (4). All of these experiments exposed the seeds to soaking periods from 0 to 96 hours only. This problem can be related to oxygen deficiency under water and may in part be alleviated by oxygenation of the water but the partial pressure of oxygen should preferably be below the partial pressure of oxygen (8).

To date almost all of this work has been conducted on herbaceous species. This is due to the requirement for rapid turnover of experimental material. However, we hope to be able to formulate general predictive behavioural patterns by seed type. At this stage it is possible to make an intuitive guess as to seed behavioural patterns under flooding but this has not yet been quantified. This is based largely on metabolic behaviour and germination tests.

Frequently when seeds suffer metabolic damage a secondary form of damage follows. It is known that alcohol fermentation in tissues frequently leads to membrane damage. In seeds this is often observed as damage to the seedling meristem and may sometimes be a lethal syndrome.

I have recently studied another type of secondary damage. After flooding, seeds may germinate apparently normally if the treatment was not too severe. However, my experiments have shown a reduction in height of the established seedling in a number of species, even though those species subjected to soaking had been soaked for up to 96 hours ahead of sowing time.

Avoidance of soaking injury 1. Seeds of herbaceous species might be injured after only 48 hours of soaking. Usually, howev-

er, a soaking period up to 8 hours will be advantageous (for example, *Pisum sativum* L).

2. Seeds of woody ornamental species may often be soaked for much longer periods without deleterious effects. Indeed in many instances this is desirable because some types of dormancy problems may be alleviated after this treament. It is thought that germination inhibitors are leached out during this soaking period. In my laboratory we are currently working on the replacement of this treatment with growth regulator infusion into the seeds of woody ornamentals (11).

In summary we can say that both metabolic and morphological damage (which indirectly results from metabolic damage) may result from seed soaking prior to sowing but in the case of woody ornamental seeds this may not be the case during dormancy.

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PROBLEMS IN MICROPROPAGATION: CHANGE IN MORPHOGENETIC POTENTIAL AND DIFFICULTY OF PREDICTION OF SHOOT MULTIPLICATION BEHAVIOUR

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We have now reached an impasse in the use of micropropagation and tissue culture techniques. We know that these techniques are useful to us as growers and yet we still cannot take a given genus and immediately propagate it without extensive research work. However, we have gained sufficient knowledge of these practices that we should be able to make predictive models. We have been working at The University of Idaho on the problem of prediction of behaviour of plants and plant parts when cultured *in vitro*.

Current commercial micropropagation practice involves the use of shoot culturing techniques, with subcultures taken regularly (perhaps every 4 to 6 weeks). Sometimes we are advised to obtain fresh culture material regularly and yet it is much easier to repeatedly work with our already cultured, and therefore, sterile material. Our work has shown some interesting changes in shoots of Rosaceous plants after repeated subculture.

The test plants were species from the genera *Chaenomeles, Crataegus, Potentilla, Prunus* and *Spiraea*. Shoots were cultured on a modified Murashige and Skoog nutrient medium with the addition of benzyladenine and were subcultured every four weeks (3). Changes in morphogenesis and morphology of shoots and roots were recorded over a period of nine months.

It was found that shoot number increased over the first few generations and then decreased gradually in later generations. Shoot length and also leaf size decreased with each successive generation. Eventually, in some cases, the material became less shoot-like, more disorganized and callus growth increased. Root morphogenesis followed a similar pattern to that of shoots; root initiation declined gradually after the first few generations. Alteration of the balance and concentration of growth regulators supplied to the shoots did not significantly reverse this decline.

Changes in long term cultures of callus have frequently been reported, one such change being decreased organogenesis (4,5). However, such behaviour in shoot cultures has not been reported by other workers although Jones and Murashige (1), reported an increased number of deviant plants with repeated subculturing of shoots in *Aechmea fasciata* and Murashige (2) warned that culti-

vars of known instability should not be subcultured more than three to four times. From our work, it can be concluded that perhaps a number of species may be subject to both decline in vigour and changes in morphogenetic potential when maintained in culture in an actively growing state for a long period of time.

A second approach to our work in looking at the possibility of predicting the behaviour of shoot cultures has been to study plants by family. It is generally more straightforward to develop a micropropagative technique for a species in a plant family which has previously been studied in the same laboratory. In our laboratory we have specialized in the plant families Rosaceae and Ericaceae.

Although economics dictate that generally a plant needs to be fairly important commercially before it can feasibly be developed for micropropagation, we have found that if we know a general behavioural pattern for a plant family the development of a method for propagation of an additional species in that family can be hastened. In our laboratory we can develop techniques for new species in the studied plant families rapidly.

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MODERATOR ROGER DUER: Now is the time for questions for our panelists.

RALPH SHUGERT: Dr. Norton, I didn't catch the name of the genera you are working on in your micropropagation.

COLIN NORTON: With the Roseaceous plants that were referred to, we worked with *Potentilla, Spiraea, Crataegus, Chaenomeles. Prunus,* and *Pyracantha.*

BRUCE BRIGGS: When working on the items that are normally evergreens, like rhodendrons, and working on items which are deciduous, did you notice any difference in the decline of the shoot length — when they began to reduce in length during subculturing?

MARGARET NORTON: My answer to that is no. I don't

think there is really very much difference between evergreen and deciduous species. Both seem to show reduced shoot length gradually with each successive subculture.

RALPH SHUGERT: Where are your micropropagated plants now? From the lab, did they then go to the field; are they growing outside now?

MARGARET NORTON: Originally the explants were taken from plants which were mainly field-grown and then we subcultured them over a series of generations. Now some of those have got to the stage of being transferred into greenhouse conditions. But I haven't gone further than that.

RALPH SHUGERT: In other words, they are still not out of a controlled environment; they are not in the nursery area?

MARGARET NORTON: The results I presented were just purely relating to the state of the cultures, the state of the shoots in culture. They are in controlled conditions, yes. But I have transferred some of them to the greenhouse also.

RALPH SHUGERT: The ultimate performance is the thing of importance to the commercial nurseryman.

MARGARET NORTON: Yes, it is, but if you get a considerable decrease in shoot number and shoot length every time you subculture, then this is of importance to the commercial grower as well.

RALPH SHUGERT: We grow *Potentilla* cultivars. *Potentilla* is a very important flowering shrub, particularly in the eastern U.S. When it goes through microculture, is this going to disturb a cultivar down the line in my nursery that I have got to sell to the ultimate consumer?

MARGARET NORTON: I think it might . . . but I think the important thing really is that we probably shouldn't grow our shoots under many subcultures for a long period of time. We should go back to our original stock material very frequently to get new explants to be sure that our material is staying true-to-type.

COLIN NORTON: Could I just add a point in there. We believe that we are going to get material true-to-type in most instances. But in micro-culture, if you get shoots arising from callus-like material there is an increased likelihood of those not being true-to-type.

RALPH MOORE: Dr. Norton, you spoke about the ill effects of soaking the seeds in water too long, as I understood it. We have never gone back to repeat this but — we are breeders of roses — three or four years ago, we accidentally had some seed stored in the refrigerator, and the plastic bag was not folded over and sealed down as we generally do with a rubber band. The

refrigerator leaked water into this bag. How many days it was in there, we don't know, but it was icy water when I discovered it. I know it was there for days. My first impulse was — those seeds are no good and let's throw them away. But I said no, just let's go ahead and plant them; they probably won't come up very well, so we planted very thickly. Some was of *Rosa multiflora* origin, one of the dwarf forms, and some was hybrid rose seed. The hybrid seed came up about normal but the other came up as thick as hair on a dog's back and I never had such good germination in my life. I don't know if soaking in the icy water had anything to do with it; how many hours you should do it, how many days, I don't know.

COLIN NORTON: Well, maybe you are quite lucky working with roses that you have a seed with a fairly thick seed coat, so it is probably a reflection of the fact that the seeds were dormant. Maybe you just softened the seed coat with the water and it enhanced germination.

RALPH MOORE: One of the former students at Cal Poly, in Pomona, California, commented to me that they had studies in which they were soaking the seeds in a fish tank. They bubbled air through this water constantly and it gave them good germination.

COLIN NORTON: Yes, I can't really give a comment on that not knowing the species of seed.

RALPH MOORE: There were several species of seeds that they used.

COLIN NORTON: Well, all I can say is that in some instances this does work and in some instances it is detrimental, but it is better to have oxygen bubbling through than no oxygen bubbling through.

VOICE: What time of year were your *Sequoiadendron* cuttings taken?

LAUREN FINS: In the results that I presented the cuttings were taken at different times of the year. We have done some other experiments in which we looked at time of year to take cuttings; it seems that the fall is the best time to do that, from donor plants that are grown outdoors. We were taking cuttings in November when we had the best rooting success.

DALE KESTER: Coming back to the question about micropropagation. Many of our deciduous plants and strawberries and bulbs do deteriorate with time in consecutive propagations without chilling. I suspect that this is probably the thing that we need to look for. There is no reason why this little rooted growing point should act like a little runner of the strawberry that has been worked out. Nursery production of strawberries in Califor-

nia depends on having this period of chilling. Have you done anything on that aspect of micropropagation? I really suspect genetic breakdown may be something physiological.

MARGARET NORTON: Experiments that I conducted were done over a period of about a year which is not a long time, really. But I suppose the plants are going through a very rapid development phase.

There is one other point that I should have made in relation to other possible changes in relation to a question over here. I was interested in Bob Ticknor's comments about rhododendrons. He had not observed them producing flowers very readily after they had come out of tissue culture propagation. In fact, I have observed the same thing with many Roseacous species as well. I am not sure, but I think, perhaps, flowering might be decreased with an increasing number of passages through culture. So that is another possible interesting aside.

MICROPROPAGATION OF TREE FRUITS

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Over the last few years, there has been significant progress in the micropropagation of a number of tree fruits including apples, pears and peaches and plums.

Commercial nurseries have been established in Oregon and British Columbia to produce both rootstocks and scions. A number of advantages of micropropagation have been suggested:

(a) to assist the passage of new plants through quarantine
(b) to build-up plant numbers rapidly following quarantine
(c) to respond more quickly to orchardists' demands for specific types of trees
(d) to enable hard-to-root cultivars to be grown on their own roots

Despite the enthusiasm for micropropagation of tree fruits, very few plants have been grown in the field to check for uniformity of fruit. Furthermore, the economics of production have yet to be compared with the costs of conventional procedures. The research and development costs incurred to date have largely been born by government research stations or by universities. Operating costs for micropropagation must be kept as low as possible if the method is to compete with conventional propagation for established cultivars. The small rooted plantlets coming out of culture are only the first stage in a production sequence. If the methods are to be successfully adapted by the nursery industry the whole sequence from culture vessel to final tree needs to be reviewed.

At the Plant Physiology Division we have recently extended our micropropagation programme to include a range of tree fruits including apples, pears, peaches, Asian pears, persimmons and grapes. We aim to test suggested procedures, where available, on cultivars of interest to our industry and to develop new procedures where needed. Once methods have been established, it will be necessary to test whether they can be fitted into the production requirements of the nursery and fruit industries.

With regard to the proposed advantages of micropropagation the following points should be considered:

1. **Obtaining high-health plants.** Although meristem-tip culture, sometimes in conjunction with thermotherapy, is very useful for elimination of viruses, it does not remove the need for thorough indexing. In the case of some of the tree viruses, the only known indexing procedures require at least two growing seasons.

The existing thermotherapy procedures for tree fruit viruses appear to be working well.

2. **Quarantine.** Most quarantine services will insist on re-indexing fruit trees to ensure freedom from virus. There is always the possibility that:

(a) a virus has been present, but in too low a concentration to be detected in the test used in another country
(b) reinfection in the field has taken place, or
(c) a virus of concern was not included in the indexing programme of the originating country

3. **Initial multiplication following release from quarantine.** In exactly the same way that cultivars may differ in vigour, growth habit or ease of rooting, so the requirements in micropropagation will often vary. The amount of material released from quarantine is usually limited. If existing procedures work well, then rapid bulking to several thousand plants should be readily obtained within a year. If a cultivar is difficult to handle, the small amount of plant available for tests may limit an investigation of requirements and delay propagation by a year.

4. **Genetic stability.** There is no evidence to suggest that the genetic stability of plants being propagated by axillary bud proliferation will be any different than with other procedures. Some of the red sports of apple cultivars are known to be unstable and scion wood should only be collected from fruiting trees which are regularly inspected for trueness-to-type. With such cultivars, care willl be needed in micropropagation to avoid adventitious bud induction.

In the scheme suggested by Cheng (1) a high rate of shoot multiplication (30 fold per month) is considered desirable. In this case adventitious buds are likely to be induced and are difficult to distinguish from axillary buds. It may be better to use lower cytokinin levels in which shoot elongation is greater and to subculture only those shoots which clearly arise from an axillary position. A multiplication rate of 5 or 10 fold/month might still be achieved.

5. **Rootstocks versus cutting-grown trees.** Rootstocks are used for three main reasons:

(a) when scion cultivars are difficult to root
(b) for control of plant vigour and fruitfulness
(c) for resistance to adverse soil conditions or pathogens

Although many scions cultivars can be rooted using micropropagation it may still be desirable to use a rootstock for the latter two reasons. A number of apple, pear, plum and cherry rootstocks are being cultured by laboratories overseas.

It would be desirable to micropropagate new promising rootstock or scion cultivars as soon as they are released from quaran-

tine. Sufficient plants could be propagated so that within 1 to 2 years several blocks of about 0.5 hectare could be established on growers' properties in each of the main fruit-growing regions. If these trees were inspected by MAF[1] inspectors any off-types could be marked and only true-to-type trees used for further propagation. This scheme has the advantage that blocks large enough for cultivar evaluation would be rapidly established and the suitability of the cultivar for micropropagation could be established. If the cultivar was needed for large scale planting the trial blocks could provide sufficient scionwood for propagation by either conventional means or by micropropagation. In the case of rootstocks, these trials would supply information on suitability for different regions. If the rootstock was needed in large numbers either micropropagation, stools or cuttings could be used.

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[1] Ministry of Agriculture and Fisheries

APPLICATION OF MICROPROPAGATION METHODS FOR BLUEBERRIES AND TAMARILLOS

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At last year's annual meeting I presented a paper (1) outlining procedures for the micropropagation of high bush blueberries and tamarillo (tree tomato). Over the past year, we have applied these methods to a range of cultivars and several commercial laboratories are now using the methods. In this paper I wish to bring you up-to-date with our progress.

BLUEBERRIES (*Vaccinium corymbosum*)

Incubation Conditions. The standard conditions in our culture room are as follows: temperature 26 ± 1°C with lights on for 16 hr/day. Illumination is supplied by 40-watt cool-white fluorescent tubes mounted 40 cm above each shelf. Two rows of two tubes illuminate a shelf of 2,400 × 1,200 mm.

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Culture Medium. We have rechecked media requirements for multiplication and have clearly demonstrated that ½ strength Murashige and Skoog (½ MS) minerals are superior to ¼ strength MS. This was particularly evident in the case of the cultivar Darrow, where with ¼ MS minerals the growth of shoots were weak, leaves were small, and stems became red. With ½ MS the leaves expanded and the colour of both leaves and stems were green. A distinct improvement in growth was found with every cultivar tested.

The requirement for auxin was also checked and cultures were found to grow better without any naphthaleneacetic acid (NAA) in the medium.

When cytokinin levels were increased from 5 mg/l iso-pentenyladenine (IPA) to 15 mg/l there was an increase in the number of shoots formed from single node sections but shoot length was decreased. In addition, adventitious buds were found to arise, not only from the swollen basal callus of the stem, but also adventitiously from the leaf in contact with the medium. In a system in which the plants produced are going to be used as mother plants for further propagation, adventitious bud formation is considered undesirable, unless the system has been thoroughly checked for genetic stability. This might take several years. Hence the more conservative proliferation system using 5 mg/l IPA, in which any adventitious shoots can be readily identified and discarded, is recommended at this stage. Neither benzyl-adenine nor kinetin (at any concentration) can substitute for IPA in this system.

Rooting. Rooting performance has been found to vary among cultivars. Atlantic, Berkeley, Stanley, Dixie, Jersey and Blueray routinely gave 90 to 95% rooting within four weeks. Some other cultivars were much more difficult to root. These include Ivan-hoe, Bluecrop and Earliblue. Not only does the first root take longer to appear, but the small cutting begins to senesce and the final rooting percentage is reduced to around 60%.

Treatment of the cutting using a quick-dip in a 400 ppm solution of IBA in 10% alcohol or an overnight soak in a 50 ppm IBA aqueous solution proved to be toxic.

Further trials are needed to improve rooting percentage in those harder-to-root cultivars.

Subsequent Growth. Rooted plantlets of all cultivars appear to grow at a very satisfactory rate and, on transfer to propagating tubes, plants with 1 to 3 shoots over 30 cm long are produced within 4-5 months of transfer from tissue culture medium.

These procedures have now been used to produce a total of more than 6,000 plants of the following blueberry cultivars: At-

lantic, Jersey, Dixie, Stanley, Burlington, Darrow, Berkeley, Ivanhoe, Blueray, Bluecrop and Earliblue.

TAMARILLO (*Cyphomandra crassifolia* (Syn.: *C. betacea*))

Cultures are incubated under the same conditions as the blueberries. There have been no modifications to the procedures outlined last year (1). Plants which came out of culture in March, 1979, were grown in a glasshouse and flowered in November, 1979, and fruit ripened in the autumn.

There is considerable interest in a new selection of a yellow tamarillo released by the Division of Horticulture and Processing, DSIR, Auckland. This cultivar has been put into culture and proliferating cultures have been distributed to several nurseries who are now in the process of multiplying this new cultivar.

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THE ROLE OF THE ROYAL NEW ZEALAND INSTITUTE OF HORTICULTURE IN HORTICULTURAL EDUCATION AND EXAMINATION

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Historical development. An understanding in a concise manner of the origins and purpose of the Royal New Zealand Institute of Horticulture is important in reviewing the Institute's role in horticultural education.

As early as the turn of the century the Department of Agriculture was training four young orchard instructors at the State Horticultural station, Waerenga (now Te Kauwhata). Because this station began supplying fruit trees, trees, shrubs and hedge plants to growers, the nurserymen of the time banded together to protest this movement by the State. The outcome was the formation in 1904 of the New Zealand Nurserymen's and Seedsmen's Association.

It was at the conference of the Nurserymen's Association in Wellington in 1916 that Mr. A.H. Shrubshall gave a paper on the subject of "Education in Horticulture." From this beginning the idea of horticultural training began and the need evolved for an

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organisation to put the idea into action.

Between 1916 and 1922 further forays into horticultural education were made by such organisations as "The N.Z. Fruitgrower" (1919), "The N.Z. Association of Nurserymen" (1920) and the short-lived "New Zealand Bud Selection Committee" (1922). It was at the first annual conference of the New Zealand Bud Selection Committee that the proposed rules of a yet to be formed New Zealand Pomological Board were read. The objectives were bold and idealistic. However, at this meeting, instead of the Pomological Board being established, the words "New Zealand Institute of Horticulture" were inserted and the Institute was born.

An objective which has become a primary activity of the Institute since its inception has been "to promote and assist horticultural education."

The first recorded reference to any sort of formal training on a New Zealand-wide basis was in 1922 when at the N.Z. Nurserymen's Conference in Taranaki a remit was discussed to set up a "Dominion School of Horticulture." The mover of the remit was a Scotsman, Mr. Bobby Nairn but it was the Englishman, Mr. A.H. Shrubshall who had really blazed the trail in the intervening years. At subsequent conferences horticultural education and the need for a qualification in horticulture were discussed but not until 1927 was an official diploma gazetted through Parliament.

A scheme of examination had been designed stating that "the Diploma should be a guarantee of proven ability." The first examinations leading to the National Diploma in Horticulture (N.Z.) were held in 1929.

As early as 1928 moves were under way to establish formal lectures at Technical Schools (as they were then known) provided sufficient numbers of horticultural students could be registered, to justify the payment of lecturers. It is interesting to note that because the number of registered students in horticulture were less than 60 in 1931, no correspondence lessons could be arranged from the Correspondence School in Wellington. The Education Department reply stated that the Government was too busy dealing with the economic depression.

In 1932 the Examining Board of the Institute decided to ask the Education Department to provide for the teaching of Botany and General Science in all post primary schools. Not until 1946 was this to be introduced by Government.

At an Executive meeting in 1936 the Institute decided to approach the University of New Zealand asking for the establishment of a horticultural course at Massey College. But it wasn't until 1943 that the Principal of Massey advised the Institute that it would be offering instruction in horticulture for the Institute's

examinations. Lincoln College proposed setting up a course of instruction in horticulture for returned servicemen.

By 1946 Lincoln College had established its own courses leading to degree and diplomas in horticulture. Massey University began its diploma and degree courses two years later. The Chairs in Horticulture were set up at Massey in 1963 and Lincoln in 1965.

Of much significance to the Institute in 1943 was the introduction of correspondence lessons in horticultural subjects by the Department of Education through the Technical Correspondence School. (Now the Technical Correspondence Institute.)

The apprenticeship system of training in horticulture began in 1938 and a large number of apprentices continue on after gaining their Trade Certificate to pursue the N.D.H.

The partnership between the T.C.I. and the Institute's examination system has evolved into a most successful dichotomy. The T.C.I. retains two positions on the Institutes Examining Board and very close and harmonious contact is maintained between the two organisations. It is vital that this remains so for the benefit of students and for the employing industries concerned.

These brief notes indicate the historical role that the Institute has played in pioneering horticultural training, education and examination since its inception in 1922.

Sound Policies. Some basic principles and policies which have evolved and been adhered to right up to the present time are worth discussing.

Firstly, the examination of the Institute's students, who are taking the various certificates and diplomas, has become a major responsibility. Over the years there has been continual review and revision to meet changing needs. It must be noted that the Institute provides a system of examinations which lead to recognised qualifications. It does not train or educate in a formal sense. Its primary role is to guide students, to monitor their progress, to assist them in their special subject areas and to help them through the study and presentation of their theses.

Secondly, the Institute has at all times upheld the standard of its examinations. Occasionally pressure has been brought to bear to allow more passes but at no time has the Examining Board faltered in its belief that the qualifications should be "a guarantee of proven ability." This policy has been supported over the years, not only by those who have been successful in the examinations, but also by those who began the long road of study.

Thirdly, the great strength of the National Diploma in Horticulture has been in its continued emphasis on the practical side

of horticulture. Because the professions and industry of horticulture is very much a "doing" activity the need for excellence in horticultural operations, fortunately, has never been lost sight of. Perhaps the recognition of this aspect of horticulture has been one of the reasons why enrolments to take the certificates and diplomas has continued to increase almost at an alarming rate.

Fourthly, the system of approved practical placement of students and the requirement of full time horticultural work while studying has ensured that a full understanding of theory and practice is gained. This combination has produced a dedicated horticultural craftsman enabling the holder of an N.D.H. to command respect and recognition in any field of either commercial or amenity horticulture.

Fifthly, it has been the policy of the Institute to maintain links a closely as possible with the horticultural producer groups who employ their students. Up until 1971 there was one basic Diploma in Horticulture with specialisations in certain disciplines. However, after prolonged negotiations with the major producers, namely, the fruit industry, the vegetable and produce growers industry and the nursery industry, separate National Diplomas were introduced. The fourth and general diploma was maintained particularly to serve the amenity horticulture area. This general diploma today draws the greatest number of students but the N.D.H. (Nursery) has a significant following.

Horticultural Cadet Training. In 1976 there began in the Waikato-Bay of Plenty area a horticultural cadet training scheme to serve the rapidly expanding sub-tropical fruit industry. Notably the kiwifruit industry was spear-heading this development. The cadets are part of the Agricultural Training Council farm cadet scheme but last year they became horticultural cadets in their own right.

Cadet-ship is over a period of three years with block-courses, day release tuition and T.C.I. correspondence being given. Already cadet training committees have been set up in other centres, namely Hawkes Bay, Nelson, Otago and Auckland. Further committees are programmed for Gisborne, Northland, Taranaki, Southland and Canterbury.

The Institute of Horticulture is the Examining Authority for the Certificate in Horticultural Practice with oral and practical examinations now being held in Tauranga, Hawkes Bay and Otago. Enrolled cadets in 1980 totalled 209 and in 1981 there will be 276.

The Institute's role in the cadet training scheme is the examination requirements and provide the moderation required to ensure that a uniform qualification is achieved throughout New Zealand.

The Present Situation. While a claim can be made for the success of the N.D.H. system of training and examination it must be recognised that over the past five or six years there has been rapid acceleration in horticultural interest on a nation-wide scale.

The number of students who are taking or have taken examinations of the Institute over the past three years topped the 816 mark this year. The growth pattern continues not only with the Institute's students but also with the Universities.

Students registered with the Institute total considerably more than both Lincoln College and Massey University horticultural students combined.

The breakdown in registrations over the Institute's Diplomas for 1980 is as follows:

N.D.H. General	399
N.D.H. Fruit	66
N.D.H. Vegetable	39
N.D.H. Nursery Management	186
N.D. Apiculture	21
Total	711

The Examining Board of the Institute is currently revising the Examinations Approval Notice with the intention of having the updated syllabi gazetted in 1982.

Indications are that there will be a slight reduction in emphasis from botanical subjects to an increase in emphasis in horticultural management subjects.

The Thesis which continues to bother and elude many senior students will be retained. The difficulty in reading and researching to present an acceptable thesis cannot be denied and every effort is being made to offer appropriate assistance to students who do not have ready access to a University for guidance.

Theses for the N.D.H. which have been presented in recent years on a topic of propagation are as follows:

Crooks M R 1974 — Propagation of avocados

Oliver C A 1975 — The Propagation and establishment of *Coriaria pteridiodes*

Reeve J R. 1974 — A study of wood wastes utilisation of bark in horticulture and its possible uses as a growing medium for containerised plants

Small R N 1975 — An investigation into methods currently employed to control damping off in seedlings

Harris G F 1976 — Propagation of cucurbits in soil-less media

Hocking P J 1976 — Effect of hormone/fungicide combinations on the rooting of cuttings

Hills R E 1977 — An investigation into the establishment and operation of an indoor grafting unit within a general nursery

Edwards R A 1978 — An evaluation of wounding and hormone on the rooting of cuttings

The Future. It is obvious that the interest in horticulture will continue for a long time into the foreseeable future. Proof that people have accepted house plants as a permanent feature inside the home can be seen by the buoyant pot plant industry.

Proof that people are staying in their own home sections more than before can be seen by the vitality of the seed and garden centre businesses.

And proof that New Zealand can produce first quality fruit, vegetables, trees, shrubs, cut flowers, mushrooms and other crops yet to come can be seen by the ever-increasing volume of horticultural exports.

The Government now is lending its support in the way of export incentives, rural bank loans plus other incentives to encourage horticultural production. Transport and marketing will be the major problems of the future but provided quality of the product is beyond question, then the world tomorrow will continue to seek our horticultural production.

The Institute of Horticulture will continue to be vigilant in meeting the training needs of the practical horticulturist for it is this person who will be called upon to "produce the goods."

NEW GROUND FOR THE PLANT PROPAGATOR

J.R. HEVELDT

Research & Development
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New Plymouth, New Zealand

We all appreciate the fact that ground or soil is an animate mixture. If cropped ad infinitum it gradually loses its productiveness, maybe not particularly noticeable, but it does happen in fact. Consequently, injections of fertilizers and maybe fallows are necessary to improve the nutrient status and "breathing space" or soil structure

So too, with plant propagation. Too often we go about our work as it has been done for years previous seemingly apathetic of the fact that we too are very much part of the cost-price squeeze. Maybe it would do us good to have a "fallow" — to stand back, look at ourselves and inject a new stimulus into our operation.

At this stage it would be useful for us to bear in mind the concept that an individual plant has an inherent capacity to grow, flower or fruit, which is limited by its genetical make-up.

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At this stage it would be useful for us to bear in mind the concept that an individual plant has an inherent capacity to grow, flower or fruit, which is limited by its genetical make-up.

We do not know what this limit is, because almost certainly we have never realized it. There are indications, however, that growth rates far above those normally achieved are within this genetic capability. Why do we not achieve these?

The growth, or productivity, we secure from the cultivation of our plants is the product of the plant's potential capacity modified by health, and the environment in which it grows. Plant health aside we might, therefore, think of our plant as a factory which is producing below capacity because the environment creates a disincentive for the work-force (7).

Light, moisture, nutrition, and temperature are the major factors which affect the growth rate of our crops. Our failure to achieve optimisation of these leads to the comparatively poor productivity which we actually achieve. This difference between these two is the untaken harvest of the crops' potential. In a competitive world, can we afford to neglect this harvest which may be ours for the taking?

Maybe we tend to rest on our laurels too much? A simple illustration may point to potential increases.

Let's say we are quite happily plodding along producing crop x, we are setting 1,000 cuttings of x, getting 800 to root and finally 700 for sale. Five years later, instead of 1,000, we are now initiating 10,000 cuttings. If we could improve our rooting percentage by 5% and reduce deaths between GOL potting and sale by 50%, then we could increase our numbers available for sale by 1,000 units!

Most nurseries have crops they are renowned for that they "do well." But that doesn't necessarily mean that they could not *do them better still! As I see it, there are many underutilized* management tools available to the propagator. We must be innovative enough to use these resources along with the natural ability of our labour to increase our efficiency. I put it to you that the nursery industry in New Zealand is steeped in tradition. (I say this having had seven years dealing with farmers, who are normally looked upon as the standard when it comes to conservatism.)

In my experience the traditionalism I spoke of very often leads to barriers being put up immediately a new proposal is mooted. Isn't it true that at some time you have had a good idea which has been killed, or never got off the ground because of somebody else's traditional, "but we have always done it this way and it has worked," attitude. If a new technique is put forward, then perhaps with a bit of lateral thinking we could in fact establish further uses for it. As an example, consider the growth regulator Atrinal (di-kegulac sodium). It is used extensively overseas for chemical pinching of not only *Azalea* and *Rhododen-*

dron, but also many other crops such as *Pyracantha, Euonymous,* etc. Let us take this a little further then; why not use it on our stock plants to increase the number of cuttings off a given area of land? Trials have established that cuttings from Atrinal sprayed plants root just as well as those from unsprayed stock.

Another example would be controlled slow-release fertilizers such as Nutricote and Osmocote. These are management tools in their own right — to be used in the appropriate manner. Their use in soil-less composts is virtually universal. However, I wonder how many people are using it either in the propagating medium or as a surface application to callussed cuttings as referred to in numerous trials (10). Granted, where we have, shall we say, an increase in technology we have an increase in the level of expertise required to manage that technology (e.g. tissue culture).

We had an example of this recently at Duncan and Davies when we purchased a planting machine that will plant items up to F8 size, through polythene film. With the tractor-mounted machine initial trials were an apparent disaster whilst we were learning the adjustments which had to be made to suit our requirements. After a few weeks we were planting at a higher rate per man-hour than a team of manual planters with years of experience. The resulting job was not as tidy as by hand. The rows were not quite military straight, the holes in the polythene were not neat circles; however, this did not stop the product from growing just as well!

Now to touch on some of the possible "new ground" I mentioned earlier.

(a) Fertilizer for the most acceptable growth rate in soil-less culture is determined in most cases by experience. Surely soil tests would be a more certain way. Levin Horticultural Research Station has developed a quick test for NPK in soil-less mediums. This will be used as a diagnostic tool — it will allow the situation to be monitored quickly, cheaply and accurately. This will enable the grower to monitor the situation and take corrective action at the critical nutrient level rather than waiting until visual symptoms become apparent. This may well require trials to establish these critical nutrient levels. To be meaningful and repeatable a trial should be laid out statistically, be given the necessary time to run its course, and we must not preconceive the results.

(b) I would predict that less and less local peat is going to be available in the medium to long term because of environmental drainage board considerations. Pine bark is, and is going to become more and more important. We will

have to understand the different management requirements of bark such as the fact that it fixes nitrogen; e.g., a trial we carried out at Duncan and Davies recently compared different sources of bark. All mixtures had our standard mix plus 900 gm/cubic metre of ammonium nitrate. The leaf analysis was carried out approximately nine months after potting. During this time no additional fertilizers were added. Table 1 shows that the composts with high proportions of bark had lower foliar N levels, suggesting fixation of nitrogen by the bark.

Table 1. Percent nitrogen in leaves

		Casuarina	× *Cupressocyparis leylandii* 'Leighton Green'
PB	100%	1 51	1 12
PB/SAND	75 25	1 63	1 11
PB/SAND	50 50	1 69	1 22
W	100%	1 44	1 07
W	75 25	1 53	1 12
W	50.50	1.72	1.14

PB = Processed Bark W = Wanganui Bark

(c) Numerous possibilities in the growth regulator field. Such things as gibberellins which have been shown to stimulate sprouting of dormant buds — this could be of use on crops such as *Cordyline* (2, 4, 8).

Ethylene producing compounds such as ethephon may stimulate root initiation on certain herbaceous material and can also be used to overcome apical dominance. Ethephon has also been shown to be of use in overcoming dormancy in some seeds.

(d) Pre-emergence herbicides for use in field and container situations. Herbicides such as oxadiazon (Ronstar) and alachlor (Lasso) have been well proven overseas (9), as being effective herbicides whilst being non phytotoxic on a wide range of ornamentals. There is an obvious labour saving factor here. Our Nursery Research Centre has shown Ronstar to be of value (NRC Annual Report 1978).

(e) In New Zealand we persist in using black polythene bags for container production. Recently published research (11) has confirmed that very high tempertures have been recorded in the root zone — as high as 49.5°C in this case. This has connotations not only from a physical protein destruction (direct burning effect) but also the fact that at these higher temperatures the rate of release of the so-called 'slow release' fertilizers is speeded up dramatically. There could well be a place here for bags

manufactured by Panda (film-black on one side, and white on the other).

Lastly, let us consider the question; will it be profitable to strive for maximum growth. To be practical there is no doubt that the law of diminishing returns will determine that it will not be profitable. However, it might well be profitable for most nurserymen to move toward the potential productive capacity by improving the environment for their plants. This may well include breaking new ground. This will come about only when we have had a close look at the whole process of plant cultivation, including those ideas we take for granted at present. Only then, with this data, will we be in a position to make the required management decisions.

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EFFECTS OF NITROGEN, PHOSPHORUS, POTASSIUM, AND B-NINE ON THE GROWTH OF BROMPTON STOCKS *(MATTHIOLA INCANA)*

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Abstract. The effects of five levels of nitrogen (N), phosphorus (P), and potassium (K) and B-Nine (B9) on Brompton stocks *(Matthiola incana)* grown in peat/sand 1 1 (V V) were studied Nitrogen strongly promoted growth which was further enhanced by high K Deficiency symptoms occurred at low K whereas there was little demand for P, and it tended to depress the response to N A foliar spray of B9 strongly reduced height and was temporarily phytotoxic at 5000 and 6000 ppm The two concentrations offset the response to N particularly at 450 and 600g N/m^3 where there was a mild N × B9 negative interaction for foliar dry weight

INTRODUCTION

Robinson (11) stated that a "blueprint" for bedding plant production will take a long time to produce although vital progress has been made with problems of nutrition studied at Cleppa Park Research Station, U.K. However, little research has been done to examine the combined influence of nutrition and growth retardants. A study of this nature was carried out by Joiner *et al.* (8), who investigated the influence of N, P, and K and ancymidol on the growth of *Dieffenbachia.*

Stocks (*Matthiola incana*) have long been known for their high K requirements (10) and this was reaffirmed by Cahoon and Crummett (6) using sand and solution cultures. Similar techniques were also used by Semeniuk (12) and Semeniuk and Stewart (13) to study the influence of nutrition on seed production and subsequent germination, and noted a similar high K requirement. Work reported by Robinson (11) and Dight (7) has emphasised the differing nutrition of bedding plants by examining foliar nutrient levels. Robinson (11) also pointed out that species vary in their response to the various growth regulant chemicals and that any new cultivar released to the grower may require individual testing either before or after release so that an appropriate growth regulant regime is obtained.

The use of growth retardants on bedding plants has been fairly limited in New Zealand, but they are widely used on bedding plants overseas, particularly in U.S.A. (9). These chemicals can improve quality by inducing compact darker green foliage and also improve drought resistance and shelf life (4).

The objective of the experiment reported here was to evaluate the influence of added N, P, K and B-Nine (B9) on the growth of stocks and to use response surfaces to describe any

interactions between these factors. This evaluation may allow growers to use improved production techniques for stocks and other plants and also facilitate a better understanding of the relationship between nutrition and growth retardant application for bedding plants.

MATERIALS AND METHODS

Plant Species and Growing Conditions. *Matthiola incana* seedlings were raised from seed sown on 12 April 1978 and pricked out into troughs 40 days later. Eight seedlings were pricked out per trough and placed in a heated glasshouse equipped with automatic fan ventilation. The glasshouse had a maximum temperature of 5°C above ambient and a minimum of 15°C. The seedlings were hand watered when required and sprayed with maneb plus thiram (both at 1.5g/l) at 2 to 3 week intervals during the experiment for control of *Botrytis*, damping-off, and downy mildew.

Experimental Design, Media and Fertilisers. A four factor response surface Box-Hunter design, of Cochran and Cox (5), of the central composite second order type with incomplete blocks was used. It involved N, P, K and B9 growth retardant with 30 treatments arranged in 5 blocks each consisting of 3 sub-blocks and 3 replicates per treatment.

The medium used was equal parts (1:1,v:v) Southland peat (Mataura) and coarse sand (crushed shingle grit).

The fertiliser sources used in this experiment for N, P and K were Osmocote (26% N—), superphosphate (8% P), and sulphate of potash (39% K), respectively. All treatments received a basal dressing of the following: Dolomite lime, 4.5kg/m^3; Agricultural lime, 1 5kg/m^3; 75g/m^3 "Sequestrene" iron chelate (Na EDTA Fe with 12% iron); and 150g/m^3 "Sporumix A" (containing 1.14% B, 0.62% Zn, 1.27% Cu, 5.46% Mn, 0.06% Mo, 0.05% Co, 9.78% Mg). The media and fertilisers were well mixed and then transferred to 180 × 90mm troughs just prior to pricking out.

The B9 growth retardant was applied 4 weeks after pricking-out as a foliar spray using Alar (85% daminozide wettable powder) combined with a non-ionic wetting agent — Citowett at 0.25 ml/l.

Data Collection and Analysis. Plant height was measured 14 and 16 weeks after sowing. On completion of the experiments at 18 weeks (18/8/78) the plants were cut-off just above the top of the medium and the foliage oven-dried, then weighed.

Data from this experiment were statistically analysed for analysis of variance and F Test using Boxhu computer programme Data presented in graphic form in this paper were

computed from the equations of the response surfaces.

RESULTS

The response to fertiliser and growth retardant treatments is presented in Table 1 and was assessed by height measurement on two occasions (14 and 16 weeks from sowing) and dry weight at harvest.

Table 1. The significance levels for significant factors (only), standard error, coefficient of variation (CV) and percentage variation explained by the model (r^2), were as follows

	Height 14 weeks	Height 16 weeks	Dry Weight 18 weeks
N — linear	—	***	***
— quadratic	—	***	*
B9 — linear	***	***	***
— quadratic	—	—	#
Interactions			
N × P	—	—	#
N × K	—	*	—
N × B9	—	—	#
Standard Error	0 46	0.79	1.43
CV (%)	18	13	24
r^2 (%)	27	68	54

(*** = p < 0 001, ** = p < 0 01, * = p < 0 05, # = p 0 05-0 10)

Nitrogen strongly increased growth which was particularly reflected in the dry matter yields at completion of the experiment. Plants given medium to high N rates appeared more robust and darker green than those with very low or nil N. Stocks in the nil N treatment showed the most severe stunting and also death of older leaves. This is illustrated in Figure 1 taken just prior to harvest. Height measurements at 14 weeks failed to indicate a response to N but at 16 weeks the tallest plants were those receiving a combination of high N and K, as indicated by the response surface (Figure 2). Added K only stimulated additional height at the two highest N rates. Plants given increasing amounts of K were similar (Figure 3) when the other additions were at medium levels. Plants given no K showed characteristic small necrotic spots on the leaves.

Phosphorus fertilisation had little influence on growth, and plants appeared similar over the range of P treatments (Figure 4) although those at the high rate appeared a little spindly. Added P depressed the response to N particularly at 450 and 600 g N/m^3, as shown by the response surface (Figure 5). Phosphorus additions only promoted a small increase in foliar dry weight at nil or 150g N/m^3 but at medium or high N levels, P appeared detrimental.

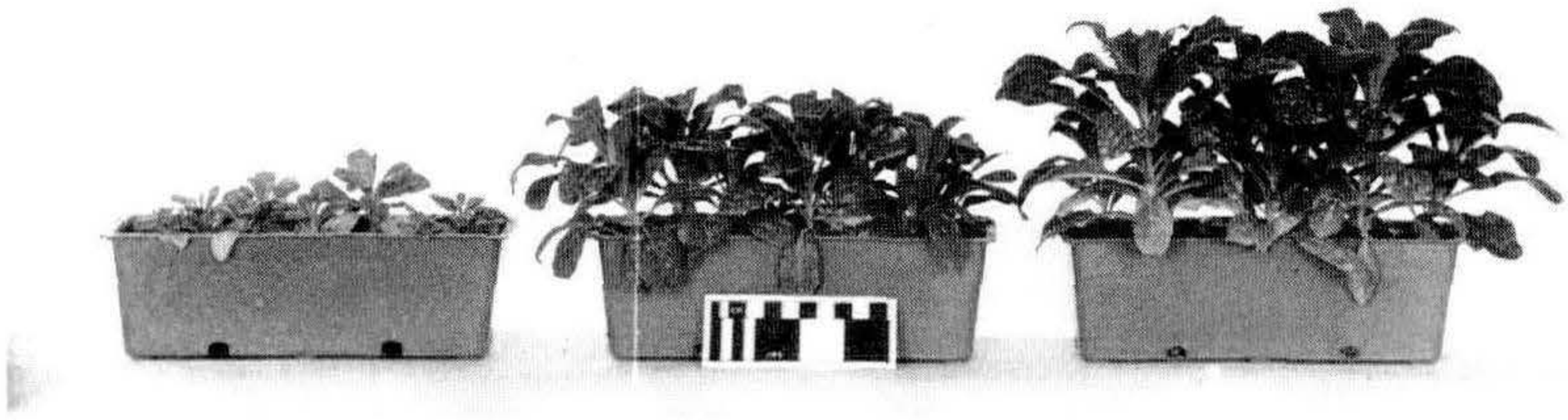

Figure 1. The response to nitrogen with P held at 200, K at 166g/m³ and B9 3000ppm.

Left to right 0, 300 and 600g N/m³ (The dimension card indicates cm & ins. for the small and large squares respectively).

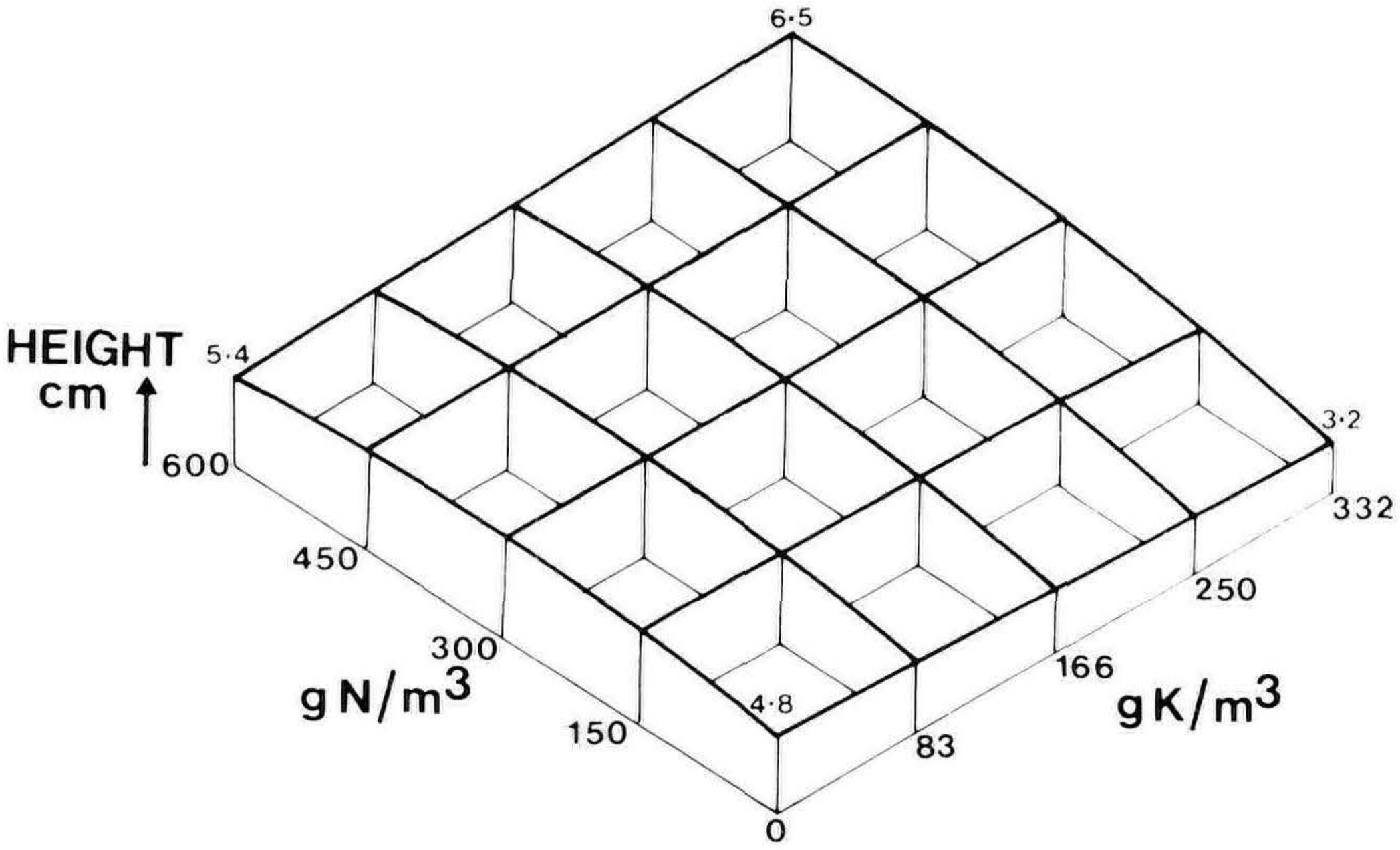

Figure 2. Interaction of N and K fertilisation on the foliage height at 16 weeks after sowing.

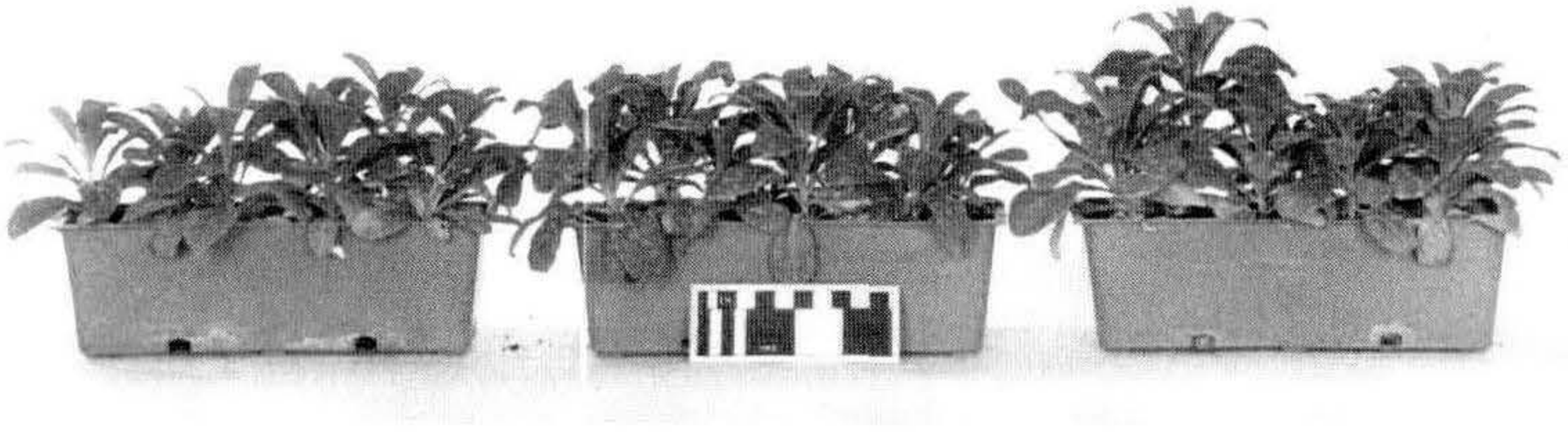

Figure 3. The response to potassium with N held at 300 g/m³, P at 200g/m³ and B9 3000ppm.

Left to right 0, 200 and 400 gK/m³.

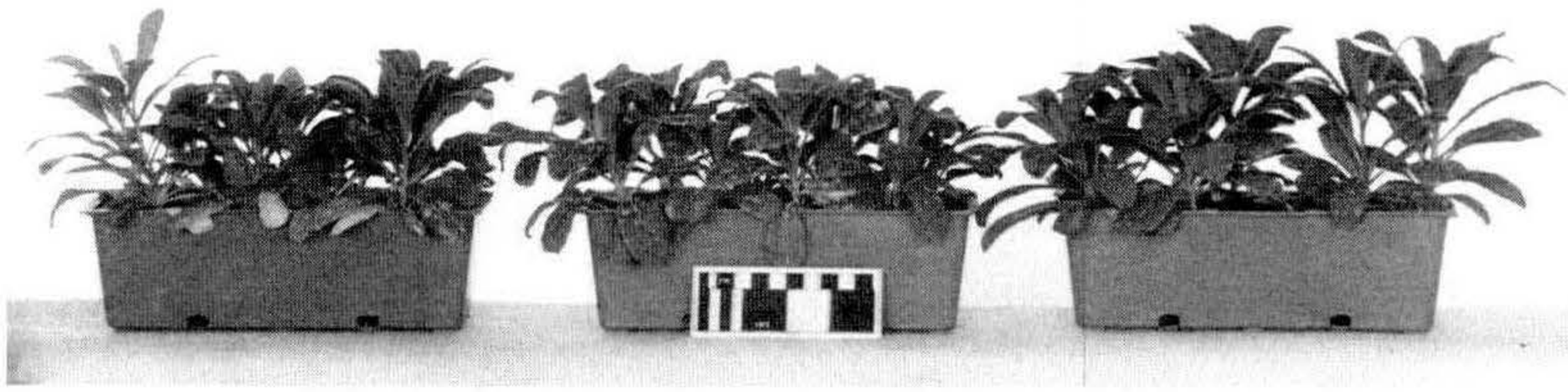

Figure 4. The response to phosphorus with N held at 300 g/m^3, K at 166g/m^3 and B9 3000ppm.

Left to right: 0,200, and 400g P/m^3.

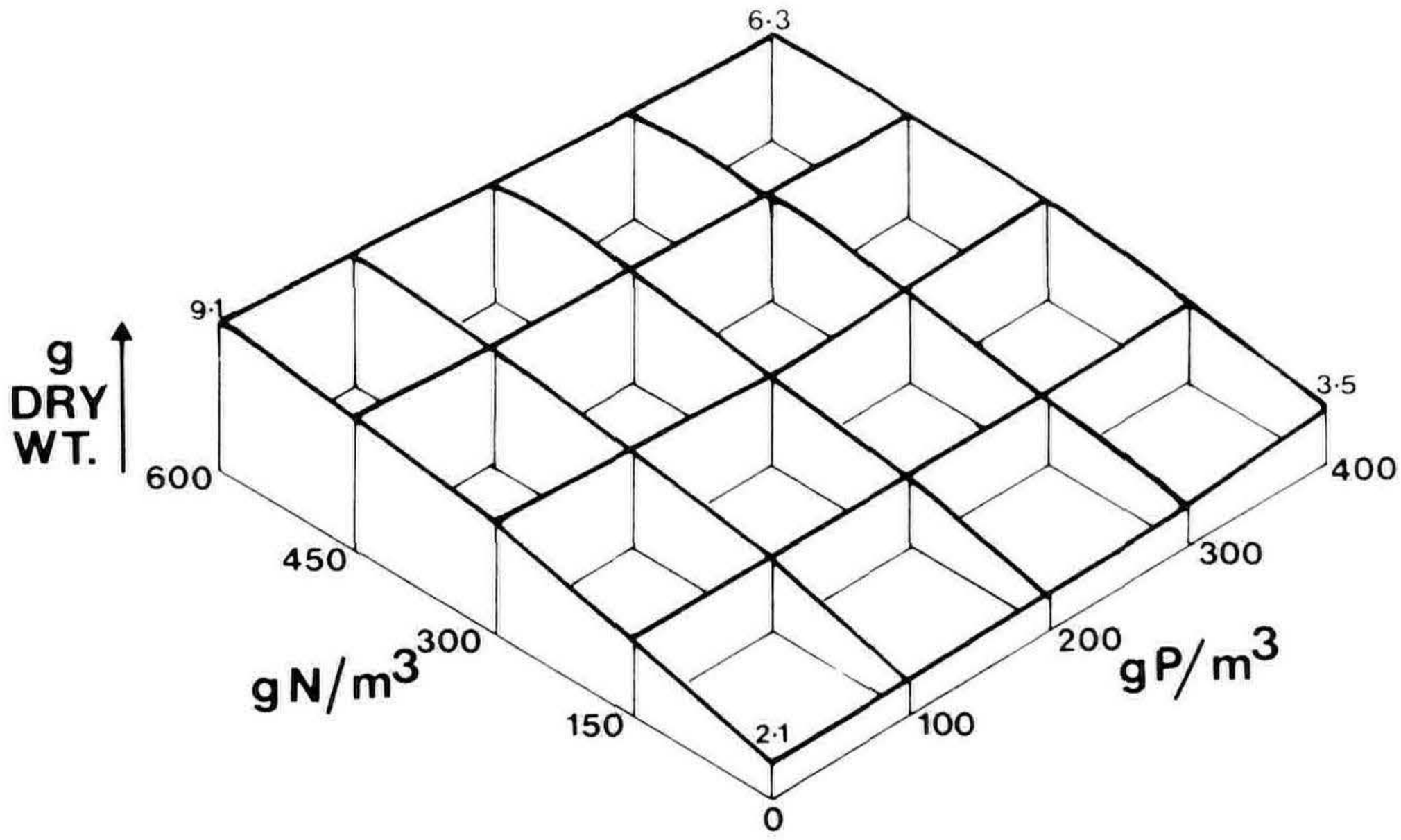

Figure 5. Interaction of N and P fertilisation on foliar dry weight.[5]

Foliar-applied B9 had a strongly depressing effect on the height of the plants, which was apparent at harvest (Figure 6) and during the experiment. There was a linear response (Figure 7) and it was notable that plants receiving 6000 ppm B9 were only half the height of untreated plants at 16 weeks. The interaction with N was mildly significant on dry matter production while N was promotory and B9 had an opposing influence. The response diagram (Figure 8) shows how increasing rates of B9 will severely depress foliar dry matter accumulation such that at 600g N/m^3 plus 6000 ppm B9 the top weight was only 4g compared to 9g per plant for unsprayed plants at the same N level. Growth depres-

sion related strongly to B9 concentration at all N rates so that there was a relatively small decrease in foliar dry weight at 1500 ppm B9, but increasing reductions at higher B9 levels.

Plants were visually rated for B9 phytotoxicity 1½ weeks after spraying. More than 50% of the plants receiving 6000 ppm B9 showed large amounts of chlorosis and some necrosis on the leaves. There was a linear relationship between phytotoxicity and spray concentration (data not shown), such that those receiving only 1500 ppm showed very few symptoms. Phytotoxicity was barely visible 4 weeks after rating and recovery was generally rapid and complete.

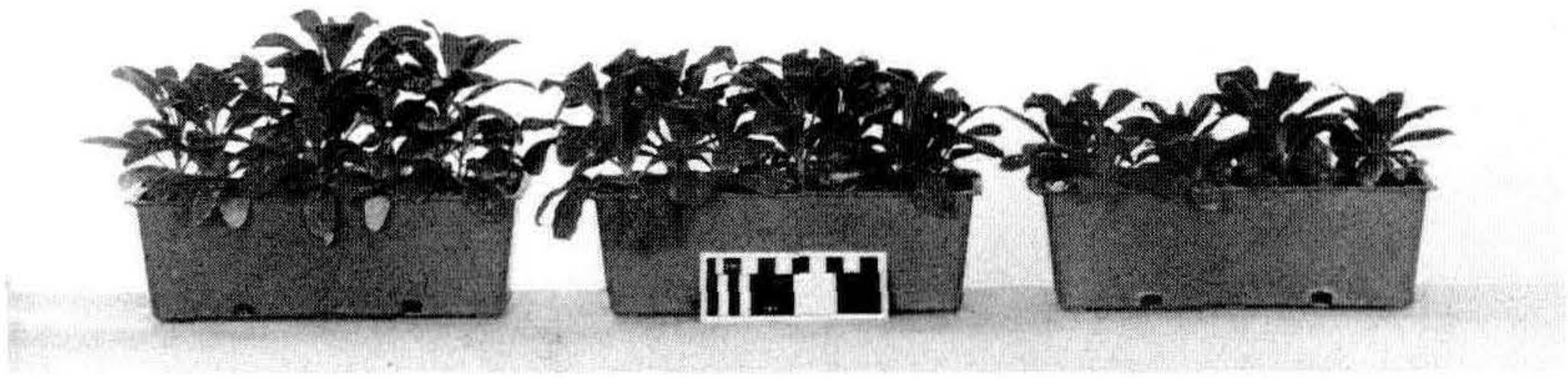

Figure 6. The influence of B9 on foliage growth with N held at 300g/m³, P at 200g/m³ and K 166g/m³.
Left to right 0, 3000 and 6000ppm B9.

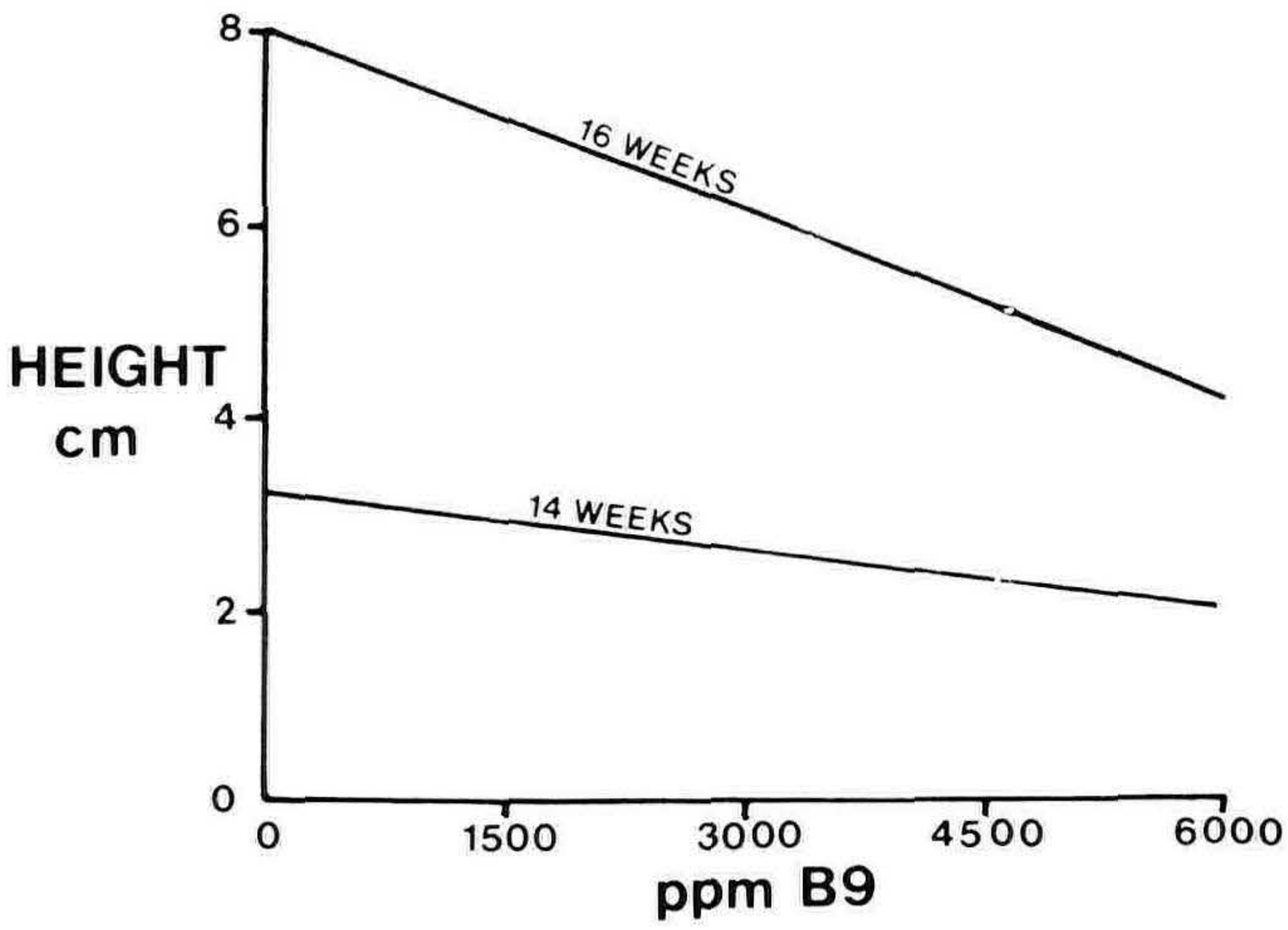

Figure 7. The influence of B9 on foliage height at 14 and 16 weeks after sowing.

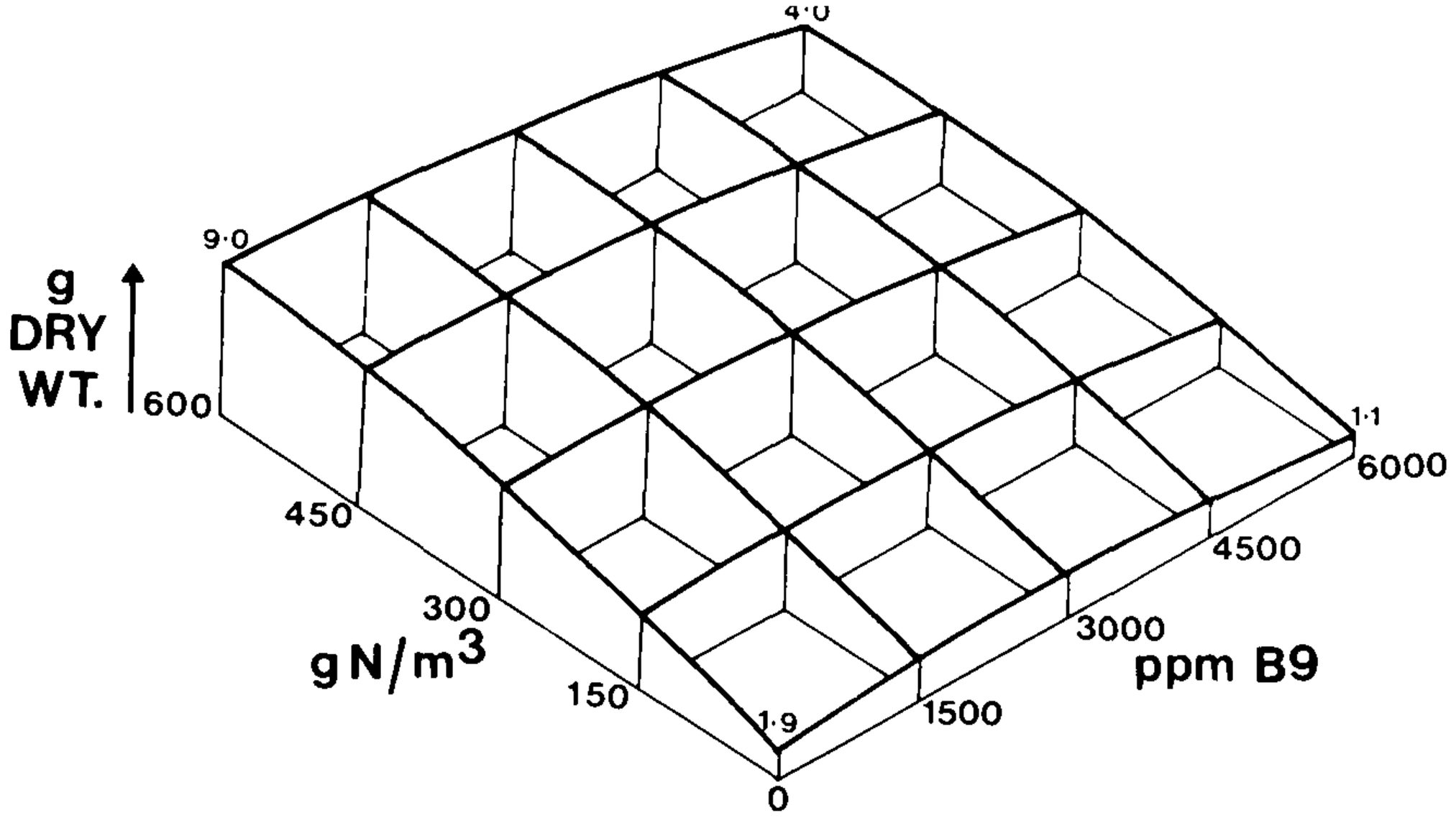

Figure 8. Interaction N fertilisation and B9 foliar application on foliar dry matter.

DISCUSSION

Dight (7) using a peat/sand (3:1) mix found that a range of bedding plants were highly responsive to added N and that inadequate levels resulted in pale small plants as was found in the work described here. Semeniuk and Stewart (13) grew *Matthiola incana* in sand using nutrient solutions and found that early removal of N gave shorter, smaller plants with fewer flowers and poorer seed production than those given a continuous N supply.

Stocks appear to have a low P requirement and a range of levels has been shown in the work reported here and by others (13) to have little influence on foliage growth. Furthermore, Semeniuk (12) noted that additional P depressed seed production and germination percentage. Cahoon and Crummett (6) found that P accumulation, which was absorbed relatively independently of the K levels from solution cultures, was only absorbed in relatively small amounts compared to N, K and Ca and primarily at the early stages of growth.

Early work by Cahoon and Crummett (6) established that stocks are a K-sensitive crop due to a high K requirement and a limited ability to obtain K from the soil. They were found to have a high threshold value for visible K deficiency symptoms (1.2 to 1.5% in the leaves) and also to normally have high foliar K levels of 4 to 6 %. They found that K uptake was most rapid in the early stages of growth and slower later when grown at low K. In the work reported here, K deficiency symptoms occurred quite early and lasted till maturity. Dight (7) reported that 300 to 400g K/m^3 provided inadequate feed for commercial bedding plants and that potassium symptoms were frequently seen in retail out-

lets. However, in this investigation, 332 K/m³ appeared to give good results, particularly when coupled with nil or low P and high N.

A single 5000 ppm foliar spray of B9 at stem elongation was reported to be sufficient for retarding the growth of bedding plants (2) and will reduce the height of petunias by one-third at this concentration (4). Cathey (3) stated that B9 is non-toxic at normal concentrations but in the work reported here, phytotoxicity was apparent 1½ weeks after spraying; however plants appeared healthy one month later. The typical characteristics (3) of more compact habit and darker green foliage, compared to unsprayed plans, was also observed.

There have been relatively few detailed studies combining growth retardant and nutrition studies, particularly on bedding plants. One such study on *Dieffenbachia* (8) indicated that the most striking results of their experiment were interactions between ancymidol and N,P,K fertilisation on shoot growth. The numbers of axillary breaks rose to a maximum with the second highest level of both treatments. Ancymidol and fertiliser levels influenced height independently. In the work reported here there was a minor interaction between N and B9 on foliar dry weight and it appears that the influence of N at medium to high rates is simply offset by B9 to a degree dependent on concentration. Medium rates of both are most likely to give well developed but relatively compact good quality stocks.

CONCLUSIONS AND PRACTICAL IMPLICATIONS

Stocks grew strongly in response to added N and K when grown in peat/sand with 6kg/m³ of lime. This work indicates that optimum growth in this medium could be obtained from a high rate of commercial fertiliser such as 3kg/m³ of Osmocote N,P,K 14/6/12 plus 0.5kg/m³ of sulphate of potash (39% K). No additional P is required.

Ball (1) recommends a porous soil with a pH of about 6 plus regular liquid feeding for stocks, as determined by soil tests. The suggested readings were 2.5, 5.0 and 30 to 40 ppm of nitrates, phosphorus, and potassium, respectively. The strong response to N and the negative influence of P reported here could be considered when following the programme recommended by Ball (1).

A foliar spray of B9 can be used to improve quality, shelf life and provide compact plants. This appears to be a useful production technique and a foliar spray of 3000 to 6000 ppm B9 can be applied when the plants begin active growth at about 4 weeks after pricking-out.

Acknowledgements. Dalgety (NZ) for the supply of Osmocote fertiliser and M.I. Spurway for technical assistance.

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ONE-YEAR FRUIT TREE PRODUCTION IN THE FIELD

EDDIE JOHNS

F.M. Winstone Ltd.,

Palmerston North, New Zealand

My horticultural scholarship took me to Australia where I studied budding and grafting; of particular interest was the production of 1-year trees from seed which is grown from spring planting, worked or budded in early summer and cut back to inserted bud to allow growth to a required height in approximately 10 to 12 months.

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First of all the budwood from selected cultivars must be first grade. Seconds cause loss and in order to obtain first grade material one either has to chase the countryside or provide a stock bed for the required needs. Healthy stock plants must be selected and planted out in prepared site with:

1. Sound drainage system.
2. Excellent windbreak, preferably disease-free.
3. Adequate irrigation, either trickle or automatic.

A high standard is a must in order to produce the first grade scion or budwood required. Maintenance is essential, e.g.:

1. Pruning programme — promotion of new growth and removal of dead or old wood.
2. Routine spray programme — a must.
3. Routine fertiliser programme — granule and liquid.

To obtain the perfect wood required is sometimes costly and time consuming but it must be done to get first grade wood.

Collection of budwood: Pick more than required. Collect in the morning, 5 to 6 am before the sun starts to affect the foliage; pick only the best growth and start at the top of the tree, selecting thin slender growth of the current season only. Place straight in drum of water or plastic bag with holes to prevent heating up and sweating. As soon as possible, run cool water through picked branches and place in shade or chilly bin with crushed ice to maintain a cool temperature so that the budwood does not desiccate or deteriorate fast. Remove leaves as soon as possible, leave leaf stalk long enough for budder to handle in his fingers after slicing off budwood stick.

Bud storage: If unable to use budwood immediately place bud sticks for storage in a roll of newspaper, spaced out in that roll with the bottom end of sticks level and at end of paper roll. Moisten paper and budwood, and place in plastic bag; seal with freezer ties and place in refrigerator. Unsealed bags dry out like cold meat not covered.

Temperature is crucial and the thermostat must be set at 32° to 35°F, no lower as fridge (bruise mark on wood) burns take place. No higher or budwood will move and the buds will swell and bust.

Peach, apricot, elm, and ash budwood will last up to 1½ months at this temperature without damage.

Do's and Dont's: Don't use fridge for anything else but budwood.
Don't open to inspect every few minutes, as warm air rushes in and cool air rushes out and buds start to move and swell.
Do provide a layer of protection between budwood and freezer

compartment as fridge burns affect top layer of budwood if not covered.
Do have a standby fridge for breakdowns.
Do have other power sources, e.g.: generator for power cuts.
Do get your fridge checked yearly before season starts. These are a must.

Plum budwood will only last up to 4 days in fridge as the water tends to get behind bud and affect the bud, e.g.: brown stain or botch, this tends to reduce viability; also leaving plum budwood in a can of water has the same effect only faster. Budwood sent through mail either turns up excellent, dried out, or a miniature compost heap, so be careful.

When ready for budding remove paper roll from fridge and roll in small sack and tie over shoulder, e.g.; like an arrow pouch, Robin Hood style. Other rolls taken out to field should be stored in chilled bin with ice packs.

Always label the budwood both inside paper roll and outside. Time and money are wasted in carelessness.

Stock: 'Golden Queen' peaches from seed are easy to collect from local canning factories. Seedlings are mostly virus-free. Melbourne has block of virus-free budwood and Monash University supplies stones from virus-free trees.

Sacks of seed are soaked in water for 24 hrs then placed in cool store for stratification for approximately 100 days. Dormant embryos respond to chilling after the peach flesh is removed. Never allow peach stones to sweat in full sun as reduction in viability takes place. After 100 days stratification plant out in open ground rows mid-winter.

Ground Preparation: Basic fertiliser is added at planting of the stones, using a light application only. Six weeks after germination start a fertiliser programme, using every eight weeks a light application of 11-27-11 N.P.K. Nitroform and Newfrocote slow release fertilisers may be added.

An irrigation programme is essential. Once the plant starts growing don't stop sap flow, as a stop in sap flow will delay growth up to 3 to 4 weeks.

Start a spray programme; spray with a boom sprayer every 10 to 15 days. This is most important. Budding can commence from late November to the 1st week December (late spring) and can usually continue till 3rd week January — *no later*, as the essential growth will not be obtained if it is done later in the season. Remember you are aiming for 5 ft to 6 ft growth during the summer.

Cut buds from budwood stick and look quickly for bud swelling or damage to bud. Discard if this is the case.

Make a "T" cut into stock and insert bud. Height of "T" cut is three to four inches above ground. Do not remove bottom foliage as these nourish the dormant bud.

Tie with rubber strips (perishable rubbers of German origin perish in 10 days). After 3 days remove tops of stock by ⅓ leaving ⅔ growth. This activates lower regions of plant in all dormant bud areas.

After 15 to 17 days, cut back to top of "T" cut leaving bottom foliage alone. Growth is really active in lower branches and these should be lightly trimmed back to just below inserted bud. Inserted bud should have started growth by now; when shoot growth from the bud is at secetuer length remove all lower branches.

The spray, water and fertiliser programmes are a must. Clean up understock as usual.

These procedures will produce a one-year peach, apricot, plum and ornamental rod (whip) to a height of 5 to 6 feet if the proper timing of the spray, irrigation and fertiliser programme is strictly followed. A take of 98% can be obtained but allow 10% loss for carelessness.

Some peach cultivars are slower in growth than others. With Red Haven and J.H. Hale being the slower of the cultivars these should be budded onto Golden Queen stock first to give a more extended period.

Advantages:

1. A rod (whip) is more easily handled, packed, with less freight costs.
2. Smaller root system, less transplanting shock.
3. Rod-like 2-year trees can be cut back and allow for easier training for the future framework.
4. In most cases the trees will fruit on next year's growth.
5. Fast, easy and lower retail/wholesale price.

Disadvantages:

1. Objection from customer on smaller size.
2. Production costs are 30% above normal.
3. More labour intensive in 4 months than in whole year.

Golden ash (*Fraxinus excelsior* 'Aurea'), *F.* 'Variegata', *F. oxycarpa* 'Raywoodi', *Betula pendula* 'Purpurea', *B. pendula* 'Youngii', *Ulmus procerea* 'Aurea', and *U. glabra* 'Variegata' propagated in this manner also produced excellent growth.

The temperature in Australia where I worked was 35°C day and 22°C night with snow and frost in winter. A warm tempera-

ture is essential but, most of all, correct timing of operations and procedures must be strictly followed.

THE RE-DEFINITION OF BOTANICAL NOMENCLATURE OF PALMS

PETER ENTICOTT[1]
Kumeu, New Zealand

Since the 1800's misspellings and confusion among genera and species has led to confusion in the culture of palms. I think it is important that these corrections are noted in New Zealand as many seedlings are now being raised, especially in the Auckland region. Firstly, I will summarize the genera and then the species with corrections as necessary.

Archontophoenix. A comparatively fast growing palm of which both species are fairly hardy. This genus bears some broad resemblance to *Veitchia, Ptychosperma,* and *Dictyosperma. A. alexandrae* has leaflets which will help to distinguish it from these genera; *A. cunninghamiana* does not have this distinguishing feature.

A. alexandrae — King palm or bangalow palm. Origin Australia. The trunk grows to a height of 60 to 70 feet, with a 6″ crown shaft. It has often been confused with *Seaforthia elegans* which now is an obsolete genus.

A. cunninghamiana — Magestic palm — Origin Australia. Similar to *A. alexandrae* except for these differences. The trunk is not swollen at the base and can be subject to individual variations.

Areca. Most *Areca* palms have multiple trunks, but the best known one, *A cathecu,* the betel nut palm, has a tall, thin solitary stem.

A. cathecu (sometimes spelled *catechu*).
Betel palm — Origin Malaya.
Usually the trunk grows to 30 ft high and is 2″ to 5″ thick. The name *Areca* has been much used in error. Many nurseries incorrectly speak of *Chrysalidocarpus lutscens* as the areca palm. There are many other species of *Areca* that are not cultivated widely and are little known in New Zealand.

Arecastrum. Known in many places and for many years as *Cocos plumosa,* this palm is an example of true confusion of nomenclature. In 1823 this palm was discovered and was named

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Cocos romanzoffianum. In 1860, unaware of the above naming, it was re-discovered and described in a botanical magazine, and was named *Cocos plumosa.*, under which name it was widely cultivated. In 1916 the *Cocus* family was broken up into seven genera and this particular palm was given the genus name *Arecastrum.* The palm has now become *Arecastrum romanzoffianum.* Following the rules of botanical nomenclature the species name first published has been used.

A. romanzoffianum
Queen palm — Origin Brazil.
The trunk grows to 25′ high, is 1 to 2′ in diameter, and is smooth and plainly ringed.

Butia. A genus, originally segregated from the once greatly varied genus *Cocos.* Many species have been studied, but there is so much variation in plants within a species that distinguishing characteristics are little more than tendencies. The confusion is increased, no doubt, by cross pollination.

B. capitata. Yatay palm or Jelly palm — Origin South America. The trunk grows to 20 ft high, about 18″ thick; the bottom of the trunk has a round knob, from which roots grow.

Caryota. The famous fishtail palms. The two best-known species are *C. mitis* with clustered multiple trunks, and the single-trunked *C. urens.* Both species can be grown successfully in New Zealand, being reasonably quick growing. Botanical naming has been straightforward with no confusion in naming.

C. mitis
Fishtail palm — Origin India and Malaya. It produces several trunks, growing to 25′ to 40′ high.

C. urens
Single trunk species, 40 to 60 ft high.

Chamaedorea. A group of shade-loving, small, graceful, and delicate palms. The slender, green trunks, which may be single or clustered, are often attractively ringed or jointed. *Chamaedorea* is a large and imperfectly-known genus with over 100 species being described in Mexico and Central South America alone. True breeding requires a male and female of the same species and the positive identification of most cultivated species is puzzling and hazardous.

C. erumpens — Origin Mexico; the trunk grows up to 10′ high with 40 or 50 canes in a clump.

C. geonomiformis. Grows to 4 ft high with individual leaves.

Chamaerops. The European fan palm is the only palm native to Europe. It is amongst the hardiest of palms, and very widely planted. It is an oddity in nomenclature because, as one species

of one genus, it grows in much more variable forms than one would ordinarily expect. Under the same specific name, it may have one trunk, or many; it may be 4 ft tall or 20 ft tall; it may have green leaves, or glauces — blue leaves. Certain forms have at times been given other names, but only as varieties of the species *C. humilis* and not as separate species.

C. humilis is usually a low, bushy palm, forming a clump of several trunks. Its deeply cut leaves are palmate.

Chrysalidocarpus. Unfortunately, nurserymen often still refer to this *Chrysalidocarpus* plant as the *Areca* palm. Although this name has been erroneous for many years do not confuse the genus *Chrysalidocarpus* with the genus *Areca.* Both are valid.

C. lutescens. Origin Madagascar. The trunk often growing up to 25′ high, 4-6 in. in diameter, often clumping.

Cocos nucifera. Coconut palm; origin Pacific Islands. The coconut is the most important of all the cultivated palms. It is a typically tropical plant and thrives best where the mean average temperature is above 72°F, where there is no seasonal differences in temperature, and where there is an annual rainfall of well over 40 inches. Many varieties are cultivated.

Collinia elegans. (Formerly *Chamaedorea elegans*). A graceful, dainty palm, well known in New Zealand for its indoor use and once under the incorrect name of *Neanthe bella.* Growing to about 4 ft tall.

Hedyscepe canterburyana. Very similar to *Howea,* from which it differs only in some details of the flowers. Native to Lord Howe Island in the South Pacific. It grows more slowly than *Howea.* Seldom grown under cultivation except perhaps mistakenly as *Howea.*

Kentia. As currently understood, there are only two true species of the genus *Kentia.* They are *K. procera,* native to New Guinea, and *K. ramsayi,* native to northern Australia. Some 50 species names have been claimed as *Kentia,* but most of them upon closer study have been transferred to other genera. Consequently for years many palms have been erroneously grown and sold as *Kentia.*

K. baurei	is correctly	*Rhopalostylis baueri*
K. belmoreana	"	*Howea belmoreana*
K. canterburyana	"	*Hedyscepe canterburyana*
K. forsteriana	"	*Howea forsteriana*

Howea belmoreana. Origin Lord Howe Island. Sentry palm. The history of confusion in nomenclature dates back to 1870; the naming is still under confusion and only further study will clarify this. Trunk growing to 20 ft or more and expanded at base.

Howea forsteriana. Origin Lord Howe Island. Sentry palm. The trunk growing to 40 ft or more, and not enlarged at base. This species is much more common in cultivation than *Howea belmoreana.*

It may prove easy to remember that the species beginning with "f" is the flat palm, with flat and not upward arching leaves.

Jubaea spectabilis. Origin Chile — Chilean wine palm. *Jubaea* has only one species, *J. spectabilis,* which in South America grows further south of the equator than any other palm. *Jubaea* trunks are probably the thickest of all palm trunks; growing to a height of 80 ft or more, 4 to 6 ft in diameter, studded with scars of old leaf bases. Some of the best specimens in New Zealand are growing on Kawau Island.

Livistona. A group of palms native to Asia, Malaya, New Guinea; and Australia. The species show great variety but almost all have spiny, slender, fairly long petioles, with toothed edges, and circular palmate leaves.

L. australis. Origin — Australia, trunk growing to 60 ft or more in height.

L. chinensis. Origin — Central China — Chinese fan palm. Trunk growing 20 to 30 ft in height, 8 to 10 in thick.

L. rotundifolia. Origin Malaya. Trunk growing to 50 ft in height and up to 7 in in diameter, slender, brown.

Phoenix. Native only to tropical Africa and Asia. *Phoenix* is easily recognized by two characteristics that are always present in the genus.

1. The lower few, basal leaflets of each leaf are long green spines.

2. The leaflets are always folded into their stems in such a way that the edges turn upward, the inside of the pleat facing the sky.

It is difficult to identify the exact species of any *Phoenix.* The surest identifying characteristics are in the male flowers and in the fruit. Since trees are unisexual, these two parts are not found on any plant. Except in areas where only one species occurs, or where special precautions are taken cross-pollination is frequent and there will be more hybrids than thoroughbreds.

P. canariensis — Canary Island date palm. Origin — Canary Islands. Trunk 50 to 60 ft in height, very stout; leaf bases adhere for many years, forming a mass 4 ft in diameter.

P. dactylifera Date palm — origin West Asia and North Africa. Trunk growing to 100 ft or more, often suckering at the base. The only *Phoenix* species that bears commercial dates. Will grow in New Zealand but does not fruit.

P. roebelenii — Dwarf date palm. Origin — China or possibly Vietnam. Trunk growing to 2 to 6 ft tall, often clustered.

P. sylvestris Wild date palm, silver date palm. *P. sylvestris* is supposed by some to be the parent stock of all the species of *Phoenix*. Trunk 30 to 50 ft in height; trunk is usually set on a mass of exposed root-like structures several feet high.

Ptychosperma. A genus whose name has been surrounded with confusion and whose history is too involved to be traced. The confusion is due to honest mstakes made long ago and compounded when new genera were formed.

P. elegans Solitaire palm — Origin — Queensland Australia. Trunk 20 ft in height, slender up to 3 to 4 in thick, very smooth and prominently ringed.

P. macarthurii MacArthur Palm — Origin New Guinea. Trunk usually to 10 ft tall, sometimes up to 20 ft; 1 to 3 in thick with clustered trunks.

Rhapis. Because of frequent cross-pollination, the two species usually cultivated are sometimes difficult to distinguish. These palms seem to grow very differently under varying circumstances. No really complete and final study can be made, since there is no assurance that it bears the correct original name.

R. excelsa Lady palm — Origin Southern China. Trunk, multiple up to 15 ft tall, forming delicate graceful clusters.

R. humilis Trunks are more slender than *R. excelsa* and do not reach as great a height.

Rhopalostylis

R. baueri var. *cheesmanii* Origin Kermadec Islands. Similar to *Archontophoenix* type foliage now been grown in Auckland successfully.

R. sapida Nikau palm — Origin New Zealand and Norfolk Island. Well known in New Zealand, probably growing as far south as Akaroa in the South Island.

Seaforthia elegans — Genus now obsolete.

Syagrus weddelliana — (formerly belonging to the *Cocos* genus). Origin —Brazil. This small graceful palm, the most common of the species, is generally seen as a potted plant for indoor use. In the juvenile state, the slim leaflets are only 3 to 6 in long and the general appearance is very delicate. Trunk 6 to 7 ft tall, slender, 2 in thick.

Trachycarpus fortunei. Origin — Central and Eastern China. Chinese windmill palm. Sometimes still found in nurseries as *Chamaerops excelsa.* Trunk growing to 10 to 40 ft high.

Washingtonia. There have been other species of *Washingtonia*, but the two species mentioned below are now generally considered to be the only two valid species. *W. filifera* is the northern species, native to California and *W. robusta* is the southern species, native to Mexico.

W. filifera Petticoat palm. Origin — California and West Arizona. Trunk growing to 50 ft tall, 3 ft in diameter and not enlarged at the base.

W. robusta Trunk brownish in colour, with conspicous rings, grows to 80 ft in height; slender with slightly expanded base. Because different types of any one species vary considerably these differences are not always clear-cut and recognisable, except in very typical cases; identification is not easy.

CONCLUSION

So, in conclusion, I think the correct seed source from the correctly named palms is necessary. I suspect many palms now being raised in Auckland are named as *Seaforthia elegans* which is now obsolete; these are probably *Archontophoenix alexandrae*. (Bot. Ed. In the U.S. these are sometimes named *A. cunninghamiana*)

REFERENCE LIST OF PALMS SUITABLE FOR NEW ZEALAND

Archontophoenix alexandrae
Archontophoenix cunninghamiana — (syn. *Seaforthia elegans)*
Archontophoenix Cunninghami — misspelt
Areca cathecu — confused with *Areca lutscens*
confused with *Chrysalidocarpus lutscens*
Arecastrum romanzoffianum — (Syn. *Cocos plumosa)*
Butia capitata — (Syn *Cocos yatay;*
confused with *Syagrus weddelliana, Cocus weddelliana.*
Caryota mitis
Caryota urens
Chamaedorea elegans — was *Collins elegans* or *Neanthe bella*
Chamaerops humilis
Chrysalidocarpus lutescens — confused with *Areca lutscens*
Cocus nucifera
Hedyscepe canterburyana — was known as *Kentia canterburyana.*
Howea belmoreana — was known as *Kentia belmoreana.*
Howeia forsteriana — was known as *Kentia forsteriana.*
Jubaea Spectabilis
Livistona australis — only seedling varieties sometimes give confuson.
Livistona chinensis — only seedling varieties sometimes give confusion.
Livistona rotundifolia — only seedling varieties smetimes give confusion.
Phoenix canariensis
Phoenix dactylifera — Sometimes confused as same palm
Species often hybridising
Phoenix sylvestris
Ptychosperma elegans — confused with *Seaforthia elegans, Archontophoenix cunninghamiana*

Ptychosperma Macarthurii
Rhapis excelsa — Often misspelled *Rhaphis*, or confused with *Raphia-fuffia* of Madagascar
Phapis humilis
Rhopalostylis sapida
Rhopalostylis baueri var cheesmanii — Often sold as *Seaforthia* in Auckland.
Syagrus weddelliana — confused with *Cocos plumosa* and (Syn. *Cocos weddelliana)*
Trachycarpus fortunei — has been named *T. excelsa* and *Chamaerops excelsa.*
Washingtonia filifera — has been confused as *W. robusta* and *Pritchardia filifera.*

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PRODUCTION OF ULMUS PROCERA 'VAN HOUTTEI' BY CUTTINGS

IAN FANKHAUSER
Duncan & Davies Ltd.,
New Plymouth, New Zealand

The golden elm, *Ulmus procera* 'Van Houttei' is native to southern England and has been used in their landscape being a good contrast planted amongst other types of trees. An established tree is resistant to wind, drought and excessive moisture. This tree is a difficult subject to produce but is worthwhile as it is a popular garden plant. Up until 1971 we used to root-graft elms with an 80% success rate. They were grafted by the whip and tongue method onto roots of 2 year old *Ulmus parviflora* seedlings. They were tied with raffia and planted *in situ* in the field where it was important to bury the graft union below ground level to prevent dehydration. Plants were saleable in 1 to 2 years from grafting.

In 1971 trials were made producing them from softwood and hardwood cuttings. For softwood cuttings half-ripe tips and firmer stems were used dipped in various hormones. The results were: with 0.37% NAA, 60% rooting; 0.6% IBA, 70% rooting; a 50/50 mixture of 0.37% NAA and 0.8% IBA, 75% rooting; Rootone C, 50% rooting; 0.125% IBA liquid, 50% rooting, and no hormone, 5% rooting. We now use the mixture of NAA and IBA on tip cuttings. For hardwoods, heavier wood was used, with a 70% take using 0.8% IBA; 40% rooting with 1% IBA; 50% rooting with the mixture of IBA and NAA; and 5% rooting with no hormone. We now use 0.8% IBA, with an average take of 60%+ over the years. Both methods have proved successful as they are

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less costly to produce and require less skill than grafting. With grafting, one person can do 300 to 400 per working day, compared to 1200 and 800 per day for softwoods and hardwoods, respectively.

Method 1 — Softwood cuttings: The stock plants need to be grown in a sheltered area to produce strong healthy cutting material. The cuttings are collected from November to late December (late spring to mid-summer) when the wood is firm and about and 4 mm thick. They are put into plastic bags, lightly misted over, the bags sealed and kept in a shady, cool position until taken to the propagation shed. There they are put in the cool store at 10°C to remove the field heat. Particular care must be taken not to crush or bruise the leaves through the various stages, as leaf damage can result in the loss of the crop. Before the cuttings are made the material is dipped in a captan solution of 85 gms per 14 litres of water, then drained. The cutting is cut to 150 mm long under a node; the lower leaf is removed and the remaining leaves trimmed where necessary. It is lightly wounded and dipped in the mixture of NAA and IBA powders. They are set in plixie trays in a 3-2-1 sawdust/peat/sand medium. The foliage is kept moist at all times before they go into the poly house as they dehydrate very quickly.

In the house it is imperative to have very close conditions; that is, high mist, no air movement and very heavy shade initially. Extra shade can be applied by hanging black sarlon cloth over the crop. Bottom heat is maintained between 20° and 25°C. Good hygiene is required, removing any fungus as it appears and applying fungicide and insecticide sprays fortnightly. Rooting takes 6 to 8 weeks with a 70%+ strike. Care must be taken hardening off, beginning when the root initials start, doing it gradually over a 3-week period.

When rooted the cuttings are potted into a PB1, returning them back under mist or similar conditions for four weeks. Once again, care must be taken hardening off before shifting into shade. It is necessary to keep the plants growing through the summer and they should be 50 cm to 1 meter high by autumn. Being this size, overwintering losses will be minimal. In the spring the cuttings are field-planted where they will remain for two years during which time they are staked, tied, and trimmed to get a 2 to 3 meter branched tree: This type of cutting tends to make a smaller, more branched plant than those started by hardwood cuttings.

Method 2 — Hardwood cuttings: For hardwood cuttings a sheltered site needs to be selected and the ground prepared during late summer to autumn. The soil is treated with chloropicrin at 368 litres per hectare, then it is fertilised two weeks later

with "Osflo" (chicken manure, and timber shavings) at two tonnes per acre. Sheets of black polythene mulch is then laid for the cuttings.

Wood between 1cm and 2cm is collected from the previous summer's growth in mid-winter when it is dormant and fully matured. The cuttings are made 20cm to 26cm long, wounded and dipped in 0.8% IBA powder. Holes are punched through the polythene 12cm by 12cm apart, and the cuttings set through these, pushing the base 8cm into the soil. Make sure the polythene does not stick to the base of the cutting as this seals them off and they generally die. It is beneficial if the cuttings can be covered with a temporary shade house as this protects the spring growth from the wind and sun.

During the season the cuttings require plenty of irrigation. This is especially so in the spring when they come into growth as they may not all be well rooted enough to support the leaf growth. They need to be staked and tied to produce a good straight leader; some trimming of lateral growth and multiple leaders is needed. Weed control is important to reduce competition with the cuttings as is pesticide control to produce healthy plants. These cuttings should reach a height of between 135cm to 370cm rods by the next autumn with a 60%+ take. The larger plants can be sold as rods (whips) the next winter and the rest as branched plants the following year.

CONCLUSIONS:

The main advantage of softwood cuttings is that less stock is required. The disadvantages are they require more costly propagation facilities and have to be potted; extreme care is required at every stage of handling.

The advantages of hardwood cuttings are that they are less costly to produce being grown outside; a more robust plant is developed and the plant is saleable sooner. The disadvantages are that a lot of stock is required and there are physiological factors involved which are beyond the nurseryman's control.

We produce elms by both methods as it is a safeguard against one crop failing and less cutting material is required at any one time.

PRODUCTION OF *SEQUOIADENDRON GIGANTEUM* BY CUTTINGS

GRAEME C. PLATT

Platt's Nursery
Albany, New Zealand

Weighing in at approximately 2,500 tons, with a height of 269 ft. the world's largest trees — *Sequoiadendron giganteum*, are magnificent giants. Some excellent specimens are to be seen in parks, gardens and on farms in this country, from Auckland in the north to Southland and Otago. These trees do well in most soil types, except heavy clays or soil with poor drainage. The best specimens are to be seen in the colder parts of the country in free-draining soils. Some are growing to perfection on shingly soils in the south.

Our first efforts to propagate these trees from seeds were totally unsuccessful. All seed obtained from our local trees or the Forest Service proved to be sterile. We then decided to try vegetative propagation. Cuttings were obtained in mid-winter from a young tree approximately 15 ft. high. All cuttings were obtained from the lower branches as I had no desire to destroy the natural character of this tree by removing the upper terminal shoots. Most cuttings were between 5″ and 8″ long, and would best be described as mature wood. All cuttings were hormone-treated with indole-3-butyric acid, at 3,000 parts per million in 50% ethyl alcohol.

The cuttings were planted in ¼″ down-washed scoria — an excellent open propagation medium — and placed in an unheated glasshouse. There they did little for six months, except grow a large ugly knob of callus tissue on the base. Those that didn't develop callus tissue died during the summer. By autumn most of the remaining cuttings — about 80% — were showing new growth. These were removed from the propagating tray and displayed a motley assortment of roots. Many had developed only one root about 8″ long coming out of the knob of callus tissue, and at right-angles to the cutting. This root promptly broke off during potting-up. To minimise further root damage, we pruned back all roots to fit comfortably into the propagation tubes in 100% granulated pine-bark with no fertiiser. Fertiliser was spread over the top of the trays of tubes two to three weeks after pricking out. This procedure eliminates mixing potting mix, and also overcomes fertiliser shock at pricking out — a procedure which is now standard practice at our nursery with all plants. Once established in tubes, the young trees were potted up into one-gallon containers in 100% granulated pine bark, where they had to be staked, as many of the young trees continued to grow

as if they were still a lateral branch. Staking eliminated this characteristic after the first period of rapid growth.

From this stage on, no peculiar difficulties were encountered. Nearly all young trees get past the lateral stage and develop firm, woody trunks, suffering from no pests or diseases. We have been able to grow on the young trees to 6 ft. in height two years after planting in the ground. We have now repeated this technique over a number of years, and have found that we can expect approximately a 75% take. Hormone treatment does not appear to be that important, as those that were not treated one year rooted just as well.

In conclusion, I can see no reason why *Sequoiadendron giganteum* cannot be produced in large numbers for forestry or amenity purposes from cuttings obtained from young trees. However, it is important that propagation is not rushed, as these cuttings are slow to root, and any efforts to hustle them along gets you nowhere. With its excellent aesthetic appearance and quality timber, this is a tree to be considered by all nurserymen involved in the growing of quality trees.

PROPAGATION OF MARRAM GRASS

K.L. DAVEY
New Plymouth City Council Parks & Recreation Dept.
New Plymouth, New Zealand

Marram *(Ammophila arenaria)* is a strong growing coastal grass, used extensively throughout the temperate regions in attempts to stabilize coastal sand dunes. At present marram propagation is a wet weather job; our aim is to produce well rooted plants in tubes suitable for direct planting for dune stabilization. It grows rather like an extra strong couch grass *(Agropyron repens)* in that it produces long rhizomes up to 1cm thick that terminate in clusters of leafy shoots. This provided us with two types of propagation material.

1. The rhizomes that can be used as:
   a. One to two node cuttings inserted vertically in the rooting medium.
   b. Cut into lengths to suit a seed tray, and laid on the rooting medium or just covered. Bud growth is rapid (2 to 3 days) and root initials show after about 5 to 7 days; development is quite rapid and well-rooted cuttings can be potted in 14 to 18 days. The longer sections of rhizome laid horizontally produce shoots from nearly

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every node; the shoot itself produces roots from it's base, not from the old rhizome. Once these shoots are well-rooted, they can be cut from the old rhizome and potted on.

2. The clusters of leafy shoots at the ends of the rhizomes can be divided into single shoots and treated like ordinary cuttings; again rooting is rapid.

We are growing marram in a small area as against growing it as a field crop; it enables us to hold a large number of plants in a fairly small area. By growing marram this way we are getting a rootball that will extend below the drier top layer of sand and can carry on growing without the check that field grown plants get.

To a limited extent we have tried this method on:

1. Spinifex *(Spinifex hirsutus)*, another coastal grass of value for sand stabilization; it responds to the same treatment but at a slower rate.
2. Pingao *(Desmoschoenus spiralis)* — This is a native sand dune stabilizer, It is a much more robust plant with thick stolons up to 2 cm in diameter. Pingao rhizomes have very close internodes and when cut into 5 to 10 cm lengths and planted vertically, many of the dormant axillary buds break and produce strong shoots. Both tip cuttings and these axillary shoots appear to be slow rooting, but more study needs to be done with this plant.

LOOKING AT OVERSEAS NURSERIES

F.W.G. SCOTT

Topline Nurseries
Auckland, New Zealand

The main purpose of our trip was to sell plants and to advise on how to handle and grow New Zealand plants. We travelled in U.S.A., England and France.

In America we visited some nurseries in Miami, Florida, Phoenix, Arizona, and one in Texas, plus had an opportunity of setting up a booth at the Pacific Horticultural Trade Show, Long Beach, California.

The Pacific Horticultural Trade Show was staged at Long Beach Convention Centre, about an hour's drive from Los Angeles airport. There are 677 booths representing over 365 exhibitors. The displays of horticultural products range from nursery sup-

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plies, flowers, seed and fertilizer through to lawn and garden equipment, tractors and garden lighting, so it would take many hours to go through and see everything. During the show we found most people loved New Zealand plants because of the different types of foliage and the colours we have to offer.

In all nurseries they try to produce a plant with the minimal amount of effort and cost. At the nurseries I visited they potted from liners which were only about 6″ high, into 1 to 2 gallon containers. In some cases I saw liners in 5 gallon containers. The containers were mainly hard plastic but some nurseries were using 1 gallon tin cans. They could buy these quite cheaply.

Growing media ranged from a John Innes compost to a very heavy peat, depending on what was readily available in each state. I think in New Zealand a lot of nurseries will go out of their way to buy peat for use as our basic ingredient, whereas they could be using sawdust or bark chips.

In one nursery they would have a turnover of plants twice a year. The first one in 5 months and the second would take 7 months, the latter requiring some cooler periods. The climate in Miami in summer is very hot and humid, almost tropical. The days we were there the daytime temperatures were around 90° to 95°F and at night between 85° to 90°F. The differential between day and night not varying very much, for approximately 7 to 8 months.

We paid a visit to the Fairchild Tropical Gardens and had a talk with the manager. He said they had been trying to grow a number of New Zealand natives, with not very good results. *Metrosideros tomentosa* had been growing for 15 years but had never flowered. Cordylines would grow for a while but eventually die. We saw a lot of *Cortaderia sellowana* growing in private gardens, looking their best in full flower. After 3 to 4 years these plants would die also.

While in Florida we met Mr. Walter Gammel who has just finished a report on the top 100 nurseries in America, the two largest nurseries in each state, and also the size of the industry in each state.

The report is done only on wholesale growers of perennial ornamental and foliage plants for sale by retailers.

The output of wholesale nurseries in the U.S.A. exceeds $2.5 billion annually and employs over 100,000 people. The total of these nurseries combined in net worth, exceeds $20 billion.

Two major factors were discovered in making this report.

(1) Ten years ago 1/3 of the top 100 were not in nursery business or had only begun.

(2) There has been a doubling in sales within the last 10

years, even when adjusted for inflation.

The top two growers in each state account for a total of $414,125,000 sales produced on 44,668 acres. The top ten growers of the states account for $161,000,000 sales on 8,400 acres. The top five account for approximately one half of the total U.S. production. The scale begins at (No 1) which has $40 million in gross sales and ends at (No 100) at $3 million gross sales.

We have all heard of Monrovia Nurseries, Azusa, California, which is No. 5 and has an approximately total gross sales of $30 million on 600 acres. Hines Wholesale Nurseries, Inc. Santa Ana, California has approximately $20 million gross sales on 588 acres. Mid-Western Nurseries, Inc. has approximately $32.5 million sales on 6,000 acres but grows its plants in six states.

The largest producing state is Florida which has over 8,000 nurseries, gross sales of $450 million, on approximately 15,000 acres. Second comes California with 1453 nurseries covering 18,000 acres with gross sales of $400 million. Texas comes next with $160 million.

In California the top two nurseries are: No. 1 — Jackson & Perkins Co., with approximate sales of $35 million on 70 acres and, secondly, Monrovia Nursery with $30 million on 600 acres. Florida's No 1 nursery is United Brands Floriculture, with sales of $15 million on 420 acres, and No 2 is Oakdell, Inc., with sales of $10 million on 200 acres.

I have mainly talked about two states as these are the two biggest producing states in America and I had the chance to see a few nurseries in both states. This report was published in the Nursery Business magazine. Two years ago Mr. Walter Gammel was commissioned to undertake this project.

In Texas we visited one large nursery, George Plecters Nurseries. He's a grower of large palms and a large range of trees and shrubs. He does most of his own propagation but does buy in some liners of palms. Palms were grown in the open ground for a period varying between 3 years to 10 years. I saw two-year-old Cycads about 12″ high, Washingtonia's 3 years old between 3 and 4 ft. They were really beautiful. They would lift these palms and containerize them and sell them 4 months later. The heights of some of them ranged from 3 ft to 10 ft. Once potted they would recover under shade houses.

In England we travelled nearly 2000 miles, seeing nurseries from as far north as Leeds to the southwest and southeast of England. I would say their propagation methods are done as simply as possible. Throughout England and France I found they are propagating conifers using cold frames mostly. In some nurseries they sterilized the soil. Cuttings are set into soil and covered with plastic. The cuttings would root and grow for one year, then

these liners are either planted in the open ground, or containerized. Some are sold as liners.

In other nurseries, conifer cuttings were rooted under glass or tunnel houses. Once rooted, they were potted up into tubes and then placed under cold frames to grow through their winter. They were taken out in the spring and grown through to the next autumn when they were sold.

In one nursery in England they had just completed building a new propagation house. It was 100 × 30 ft tunnel house. They used 3 inch galvanized piping in three sections, each section having a curve which when put together made the hoop. These were approximately 6 ft apart along the length, held together by a common ridge at the top. For additional support for the polythene covering, thin gauge wire was strung from end to end every two ft. They were using clear polythene which was expected to last for approximately 3 to 4 years.

Inside, four raised sand beds were made, running the length of the house. For the mist system they had galvanized piping running parallel two feet above the propagating beds. Mist nozzles were placed every two feet. The nozzles put out a fine spray giving a coverage of 4 ft. They planted their cuttings in wooden trays filled with sand and were getting excellent results.

At Bloom's Nurseries in Diss, Norfolk, they were producing most of their plants in one large glasshouse. Here they had their mist lines above head height. It certainly keeps the floor and bed areas free of any plumbing and the occasional knocking and breaking off of mist nozzles.

They were producing approximately 750,000 conifers, 300,000 heaths, 100,000 alpines and 100,000 ferns.

Conifers root in plastic trays in approximately 8 to 12 weeks on bottom heat, using Seradix No 3 hormone. Heaths are propagated in Speedling propagating trays, approximately 200 per tray and the alpines are propagated in wooden trays.

One nursery in France which attracted my attention was Andre Briant Nurseries near D'Anjou. They had 12 people in propagation, 15 in containers and 20 people planting and sowing in the open ground, making a total of 47. The nursery was situated on 104 acres: 44½ acres in field grown liners, 2½ acres in seed bed production, 15 acres in stock beds, and 1¼ acres for propagation under tunnel and glass houses. The rest were uncultivated.

They had a turnover in 1979/80 of 4½ million plants, worth approximately $2,200,000. Some liners were exported to England and Holland.

Soil medium used was mainly 70% *Pinus pinaster* bark chips

and 30% peat. At the time I was there they were doing experiments with different grades of bark chips. For potting they use a potting machine doing 10,000 rooted cutting per day with three people. Liners were potted into 12 cm round pots. The main types of plants which they grew were *Cotoneaster* species, conifers, *Pyracantha* species, and a lot of *Thuja plicata* 'Atrovirens,' which were 18 months old when sold.

Cuttings of *Thuja plicata* 'Atrovirens' were taken in May, making a 4 in. long cutting. These were placed under mist, with no bottom heat in a tunnel house. In October, 5 months later, the rooted cuttings were potted in 12 cm round tubes using a bark growing medium. The potted liners were staged tightly in trays and placed under shade in cold frames. In March/April, the liners were then placed in moulded polystyrene trays that would hold approximately 30 tubes, each plant having equal spacing. These plants were grown outside in beds until October, by which time they had reached a height of 18 to 20 inches; they were then ready to be sold.

PROPAGATION — GETTING STARTED

PAUL V. BANBROOK
Cashins Nurseries Ltd
Dargaville, New Zealand

When I joined our nursery venture in late 1976, it consisted of a modest retail and an expanding wholesale division. At this time the propagation was confined to budding and grafting of assorted fruits and deciduous ornamentals in both open ground and containers.

With my interest in the broad area of plant propagation, we decided to gradually supplement our bought-in liner requirements with our own stock.

Initially we began with quick seed lines plus autumn-set cuttings but in 1979 we set up a primitive yet effective mist facility at the end of one of our polythene growing houses. A partition wall was built and covered with plastic and access to the mist room was through this.

The existing base of drainage metal was overlaid with pumice sand to a depth of about 5 cm. Mains water was ducted along an outside fence by 12 mm alkathene pipe and connected to a 12 mm solenoid valve, on the inside wall, above the mist line level.

The mist lines are 12 mm rigid PVC and the mist nozzles (Aquatron brass MK II ⅛″ base) tapped directly into the pipes

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and spaced 750 mm apart. The lines were suspended approximately 1 m above the beds by flexible wire formed into large adjustable hooks and then levelled. Brace wires were fitted horizontally from the line to prevent lateral shift.

Power was connected up for the mist control and heat bed. The mist control is a simple vane balance, with mercury switch and the heat facility is a Camplex resistance cable (HD 5034 24 m, 300 watts, 240 volt), laid approximately 2.5 m under the sand. We have it set permanently on approximately 20°C by an external thermostat. The heat bed area comprises about 1/5 of the total bed areas (approx. 27 m^2 total).

The polythene roof was whited with watered down acrylic paint, to reduce excessive heat build-up in sunny weather. This is permanent. Ventilation was provided by small frames covered with synthetic polymesh fabric at the top half of the three walls and door. The three wall vents have adjustable hinged doors which can be closed during storms. Initial adjustments to the mist frequency were difficult with excessive wetness being our first problem. However, we seem to have struck a reasonable compromise now.

At first we experimented with different proportions of sand and peat and, in some cases, sawdust but the basic 50/50 peat/pumice mix proved best. We were talked into cheaper polystyrene trays but after testing these we have decided their drainage characteristics leave a lot to be desired. We now use only the green hygiene trays for cuttings.

For hormones, we have used principally Seradix No. 3 rooting powder although quick-dip IBA at 2000 ppm in alcohol has been used experimentally.

Examples of genera propagated to date, include cuttings of *Metrosideros, Grevillea, Pittosporum, Juniperus, Coprosma, Hypericum, Acer, Lantana, Michelia,* × *Cupressocyparis, Genista, Pyracantha,* and *Choisya.*

Liquidambar, Eucalyptus, Arbutus, Pittosporum, Agathis, Casuarina, Araucaria and *Sophora* have been produced from seed.

Seedlings and cuttings are normally tubed direct into a standard UC mix and either set directly outside or kept in shade for the first month or so to adjust to their new environment depending on plant type and weather conditions.

PRODUCTION AND CULTURAL NOTES RELEVANT TO *MYOSOTIDIUM HORTENSIA*

GRAEME C. PLATT

Platt's Nursery
Albany, New Zealand

There is nothing more exasperating, as a professional horticulturist trying for years to grow a plant species without success, than to call around at a friend's place to find the plant growing to perfection in their garden. When you enquire as to how they achieved such results, you are rather off-handedly told, "Oh, that was something Mildred picked up at the Country Women's Institute"! The successful grower of the plant doesn't even know what it is.

Until the last few years, the Chatham Island forget-me-not *(Myosotidium hortensia)* has been a plant that has almost driven me to despair. We purchased numerous plants from other growers but no matter what we did with them they failed. We then obtained seed and tried to grow our own. The seeds germinated then came to nothing with most plants collapsing six months after germination.

The Chatham Island forget-me-not is an herbaceous plant that grows naturally only in the Chatham Islands. It was once abundant around the foreshore of these islands but last year I was only able to find two rather small patches. However their natural habitat on the Chathams is right on the foreshore generally under shady cliffs and a few feet above the high tide mark — often surrounded by rotting seaweed and constantly lashed with salt spray. Those plant I did find in the natural environment were perfection. They had leaves 12″ to 14″ across of the most vivid lush green you could imagine, and without chew marks or any damage by insects. When these plants are in full flower, with large bunches of sky-blue flowers, they can only be described as "exquisite". They would make a delightful addition to any cool, shady, herbaceous border, which had a rich soil and was free from severe frost.

Most references on the growing of this plant mention the need for seaweed or dead fish to be in the proximity of the root zone. Two years ago we drenched a seedbox of freshly germinated plants with seawater, taken directly from the sea. The results were dramatic. From that day onwards the rather sickly seedlings put on rapid and lush growth, and have grown extremely well. This year we have flowered plants, from which we shall be collecting our own seed for the first time.

With the seawater treatment, we have found that the plants can be grown in full sun. However, if the plant wilted it would

suffer from chronic sun scorch. Because of the very big leaves, the transpiration rate is such that the plant requires large amounts of water. I would still advise planting Chatham Island forget-me-nots in shade — not dense shade, however, as they do best with an high indirect light intensity. The main and only factor that appears to be important is the extra minerals they are picking up from seawater.

Nitrogen, phosphorus, potash, and magnesium we always used with no results, but this balanced fertiliser is now quite adequate after seawater treatment. It doesn't appear to be essential to treat these plants with seawater more than twice a year. I know many people will say they have been able to grow Chatham Island forget-me-nots without such treatment. However, after inspecting the plants of the other growers, it is my view that they would improve dramatically with this treatment. Some amateur growers are using proprietary-brand liquid seaweed fertilisers. These work just as well, but I feel it is an expensive way of buying seawater. Those of you who are fortunate enough to be able to grow this delightful plant without this treatment, probably have the missing mineral — which could possibly be sodium — in your soils.

We have found no disease problems appearing since this treatment. Slugs and snails are a major curse — the more lush you get your Chatham Island forget-me-nots, the more attractive they are to slugs and snails, which must be dealt with if you wish to have your plants looking their best.

As the Chatham Island forget-me-not is one of our most spectacular plants — and we always have a waiting list of customers wanting them — I hope this plant becomes more widely grown.

NEW ZEALAND CLEMATIS FROM CUTTINGS

TERRY C. HATCH

Joy Plants Nursery
Pukekohe East, New Zealand

It is strange that a large proportion of New Zealand plants are: (a) white-flowered, and (b) unisexual.

These two factors are well illustrated by the genus *Clematis* 'N.Z.' Of the ten species, two have white flowers and the rest have green-yellowish ones; all are evergreen. Bearing this in mind, we come to the reason for producing them from cuttings. The species most commonly grown is the showy *Clematis panicu-*

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lata, bush clematis, or Pua-whananga. In spring the bush is lit with festoons of starry white flowers on woody vines climbing over the trees and shrubs; the large 10 cm. flowers in panicles of one hundred or more.

For years it has been the practice to dig seedlings from the bush; these do not always grow and then, more often than not, very slowly. Over the past seven years I have been selecting cutting material from the wild to produce a small number of large-flowered plants. The male plants have the largest flowers, often twice the size of the female.

The plants for cutting production are marked in spring while in flower; this is not always an easy task as most have climbed 10 or more metres up a tree. In early autumn when the current season's growth has hardened, about the end of March/early April (depends on the weather), the material is gathered and given a good wash. I have found that internodal cuttings with one or two nodes, according to the length of stem between nodes, are best. Nodal cuttings root, but not as well. It doesn't hurt to remove some leaf area and they will root without any leaf but the buds don't always develop.

I use Seradix No. 2 hormone powder and stick the cuttings in pumice sand up to the node. The trays are placed in a frame without any heat and covered with clear plastic — they are watered once or twice a week.

After three weeks roots have started growing; the cuttings produce masses of roots without wounding the stem. I have tried splitting the stems and removing part of the stem — these grow, but why waste time. I don't use any fungicide spray on the plants; Benlate seems to make the leaves drop off, so all dead leaves must be removed.

Some years I have had 95% success, but most about 60%, the lowest batch being 2%, but these were taken, I feel, too late. The success rate seems to depend a lot on the summer weather and the way in which the wood has grown. More control will come in time, I hope, with cultivated stock plants.

When the cuttings are well-rooted they are potted into a bark-peat-pumice mix; some of the plants flower the following spring.

Other species I have grown are *Clematis hookeriana*, sweet scented green flowers.

Clematis forsteri — large sprays of small sweet-scented white flowers.

Clematis afoliata — leafless tangled rock plant with greenish small flowers.

These have grown just as well using the same methods of propagation described above but are not sought after by the general gardening fraternity.

REDUCING COSTS IN PLANT PROPAGATION

J.G.D. LAMB AND J.C. KELLY

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One difficulty in discussing the subject of reducing costs is that we are dealing with so many species and cultivars, propagated in so many ways, on so many nurseries. Every nursery is a unique situation. Every nursery has a different programme. Contrast this to the situation in the glasshouse industry where the yearly programme may only involve one or two crops, so that very precise control is possible. The hardy nursery stock industry is, in contrast, highly flexible; this makes it much more difficult to suggest where costs can be reduced. Every nurseryman must, therefore, examine his own situation and decide for himself on how he can make his production more efficient in terms of costs and returns.

Glasshouse food crops have reached fantastic levels in input costs. To counterbalance this the cultural parameters, such as temperature regimes, nutrition, and so on are quite clearly defined so that culture can proceed to blueprint specifications. The propagator of hardy nursery stock, on the other hand, concentrates on saving by minimum input costs. His parameters include percentage rooting, percentage 'take' in grafting, or percentage germination of seed, followed by time to reach saleable quality. Personal technical efficiency is paramount to maximise rooting of cuttings, "take" of grafts, good growth of seed, and the steady growth to uniform size of the finished product.

The human element is still crucial. Is the operator as up to date as possible in his procedures? Is he applying the results from Efford, for example, in mother stock management? Is he as up to date as possible in the use of hormones, wounding, rooting composts? These are factors in attaining high percentage success. Unnecessary application of rooting substances can be wasteful. Wounding can be a relatively slow and costly operation if it is not needed or, to the contrary, may be vital for success. If the final rooting percentage is not high the collection of the material, the application of hormones, the operation of wounding, after-*care, etc. etc. are all to a high degree wasted. I would also* emphasise that such factors as wounding or the use of hormones may not be effective if other conditions are not right. In other words they are not a cover-up for inefficiency.

This may be obvious enough, yet most textbooks discuss hormones, wounding, etc. in a general way, and it is left to the nurseryman to learn by experience. It is suggested that more research, and far more published results, are needed on these

fundamental operations in relation to individual species.

To quote an example: We have recently been involved in the propagation of alders from cuttings. At first sight this may seem a strange operation to the practising nurseryman, so a few words must be said in explanation. It is part of a research programme into short term forestry rotation for energy production by burning a woody crop. Alders are of interest as they fix nitrogen. This reduces the energy input in terms of fertilizers, their manufacture, and their application. It may become necessary to propagate special clones vegetatively, so we were asked to investigate the rooting of hardwood cuttings of three species. As alders were to us an unknown quantity, we tested the use of hormones, with and without wounding. The results are shown in Table 1.

Table 1. Rooting cuttings of three *Alnus* species under four treatments.

Treatment[1]	Species		
	A. incana	*A. glutinosa*	*A cordata*
No H, No W	2%	0%	0%
No H, W	5	0	7
H, No W	5	12	2
H, W	65	64	25

[1] H = Seradix 3, W = Wound

In general terms, most operators would accept that the application of root-promoting substances as likely to be beneficial, but in the absence of published information, how many would have considered the relatively time-consuming operation of wounding? Yet the hormone was much less effective in the absence of wounding.

A contrary result can be quoted for *Magnolia* × *soulangiana* 'Amabilis'. Here wounding had no effect, even in conjunction with hormone. (Table 2).

Table 2. Rooting of *Magnolia* × *soulangiana* 'Amabilis' cuttings under four treatments.

Treatment[1]	*Percent rooted*
No W, No H	11
W, No H	17
No W, H	91
W, H	91

[1] H = Seradix 3, W = Wound, Effect of H significant at 0.1% level

In this instance, the hormone was very effective, whether or not wounding was done.

These results are quoted as examples of the need for the publication of basic information as an aid to reducing costs through greater technical efficiency. Such knowledge is accumu-

lated by every experienced nurseryman, yet there is need for published standards against which individuals can measure their own performances. The demand for such information is shown by the success of a little booklet published at Kinsealy, giving tentative results under our own conditions.

Efforts to reduce costs in plant propagation fall into two categories.

1) Operational efficiency
2) Direct manipulation of energy input.

The examples I have been quoting fall under operational efficiency as distinct from direct energy input. The full exploitation of natural resources of the nursery come under this heading. For some growers this includes climatic advantages, such as the rooting of outdoor cuttings over the winter. At Kinsealy, for example, we can root outdoors not only deciduous spp. but also evergreens like *Hebes, Garrya, Laurus, Olearia, Escallonia,* and others which might be too risky in inland areas. Where cold frames are used we have been asked whether costly glass can be replaced with plastic. Trials with 44 different species and cultivars over the period of September-May indicated that glass could be replaced with 500 gauge polythene. If opaque polythene was used there was no need to use shading slats. In almost every case, rooting percentages under plastic were as good as, and often better, than under glass. A few examples are shown, covering conifers and broad-leaved plants.

Table 3. Cold Frames — Percent rooting under 3 types of cladding.

Species	Opaque plastic	Clear plastic	Glass
Chamaecyparis lawsoniana			
'Fraseri'	86	70	63
C. 'Castlewellan Gold'	93	76	70
Escallonia 'Apple Blossom'	76	96	56
Hebe 'Headfortii'	100	96	100
Pittosporum tenuifolium 'Silver Queen'	26	43	43
Viburnum davidii	73	93	70

A further trial the following winter with 18 species confirmed that satisfactory results could be obtained under opaque plastic and that further economy in structural cost could be obtained by using a single sheet of plastic over the whole frame. It was necessary to ensure that the plastic was stretched tightly with an adequate slope to ensure run off of rain as well as slats at intervals to support the plastic. Otherwise there were problems due to pools of water weighing down the plastic.

A previous paper (1) by one of us (J.C. Kelly) at the 1977 (Norwich) meeting demonstrated the losses that could arise from

crowding *Chamaecyparis*, especially the harder to root cultivars. Further results with broad-leaved species support these findings (Table 4).

Table 4. Cuttings rooted at three densities

Species	Month Cuttings inserted	No. of cuttings per tray (37 × 22 cm.)		
		24	40	60
Cotoneaster		*Number and percent rooted*		
'Hybridus Pendulus'	Sept.	16(67)	26(65)	35(59)
Pyracantha				
'Mohave'	Oct.	20(83)	29(72)	38(63)
Chamaecyparis pisifera				
'Boulevard'	Feb.	23(96)	30(75)	25(42)
Prunus aurocerasus				
'Otto Luyken'	Feb.	13(54)	19(47)	28(47)

Although by inserting more cuttings per unit area a greater number of rooted cuttings may be obtained, if these are expressed on a percentage basis it is seen that in some cases there can be waste of materials, labour and time. In *Cotoneaster* and *Prunus* there is not really much difference in the percentage rooted. In *Pyracantha* there is more, but in *Chamaecyparis* there is quite a substantial difference, indicating that rooting of conifers can be strongly influenced by the spacing. These are but preliminary observations but they do indicate that spacing of cuttings could be investigated in relation to species and season. One of the difficulties of advising on the results of such an experiment is that conditions vary so much on nurseries that one propagator may get better results at a closer spacing than the next owing to all round better conditions or facilities. Nevertheless these figures focus attention on overcrowding as a factor in reduced yield. The figures suggest that, under the conditions of this experiment, a fair compromise would be approximately 40 cuttings per tray.

The grower will be alert to improvements in basic technology that will lower costs by giving more reliable results in propagation. One aspect we have begun to consider at Kinsealy is the moisture level in the compost when cuttings are under plastic, especially where bottom heat is used; there could be effects from the combination of warmth and moisture — conditions conducive to decay at the base of the cutting. In *Chamaecyparis*, for example, we often find rot at the base of the cutting with roots emerging higher up. Insertion of cuttings shallowly on the assumption this would improve aeration did not indicate the cause. Next we tried applying water to the moss peat — sand (2:1) rooting mix at three levels before inserting the cuttings. The trays

remained under plastic, with rod-type thermostats set at 20°C until rooting, without further watering. Results are shown in Table 5. The moisture levels were arbitrary — 300 cc was arrived at by adding water to the dry compost and at saturation point it represented 300 cc per litre of compost; the remaining amounts are a half and a quarter of this.

Table 5. Compost moisture — effect on rooting of *Chamaecyparis* cuttings

Cultivar	Water added per litre of compost		
	75 cc	150 cc	300 cc
	Percent rooted after 10 weeks		
'Allumii'	44	28	17
'Kilmacurragh'	73	34	32

A different pattern of response was obtained from summer cuttings of *Cotinus coggyria* 'Royal Purple' (Table 6)

Table 6. Compost moisture — effect on rooting of *Cotinus* cuttings

Cultivar	Water added per litre of compost		
	300 cc*	150 cc	75 cc
Cotinus 'Royal Purple' rooting	53%	37%	20%

*Approx. saturation point.

These are but preliminary results, but they indicate the effect of the levels of water in the compost; by improved results this could contribute towards reduction in costs other than by direct energy input.

DIRECT MANIPULATION OF ENERGY INPUT

The saving of energy input at the expense of time and space is a decision that will be governed by the circumstances of the individual grower. In other words the choice is between spending money to get quicker rooting and greater throughput or having the cuttings root slowly, occupying bench space for longer periods. More than ever before careful forward planning of the propagation cycle is needed.

The propagation of heathers from hardwood cuttings is an example. By inserting hardwood cuttings under the warm bench and plastic in February they will be rooted in seven to nine weeks, hardened off, and grown on in a cold frame, initially with glass or polythene lights. By September nice plants 10 to 15 cm across will be produced.

The alternative is to substitute the cold frame and plastic method for the heated bench. This necessitates taking hardwood cuttings in October, lifting them in April for planting out in

further frames, to produce saleable plants by autumn. The respective time scales of these two methods are 7 to 8 months and 11 to 12 months. The traditional method of summer cuttings requires 15 months. Nevertheless, the use of bottom heat may be justified in certain propagation programmes, e.g. vacant space or catch cropping.

Another example of a cold frame method is the rooting of cuttings of Japanese azaleas. When energy was cheap we regarded July as a convenient time to root cuttings under the warm bench and plastic system or under mist, when rooting will have occurred six weeks later — in September. Instead cuttings can be inserted under plastic in a cold frame to be rooted by the following March. Though with bottom heat the cuttings will be rooted by autumn, any slight advantage in having them rooted then, rather than in spring may be unimportant.

Table 7. Percent rooting of azalea cuttings by two methods.

Cultivar	Method	
	CF & P	WB & P
White Lady	78	72
Addy Wery	62	82
Hinomayo	60	50
Vuyk's Scarlet	80	48
Queen Wilhelmina	46	50
Amoena	62	40

CF & P = Cold frame and plastic
WB & P = Warm bench and plastic

Apart from such possibilities in the substitution of no heat methods for bottom heat, there is the possibility of manipulation of the temperature regime. At a previous meeting (1977) an account (2) was given of experiences at Kinsealy on: a) rooting at lower base temperatures, and b) heating during night hours only. Work at Luddington and Efford has shown the possibilities of manipulating not only the base temperature, but also the base temperature in conjunction with the ambient temperature. The cheapest electricity cost at Efford was where a low ambient temperature (6°C) was combined with a low (15°C) day-only base temperature, but the cuttings occupied the bench space for longer.

The rod-type thermostat is a relatively insensitive instrument for controlling the base heat in the propagating bench. A semiconductor sensor control unit gives a much more instant and accurate control of base temperature, resulting in much reduced electricity consumption. Over a 40-day period (11th Nov. to 27th Jan.) the following results and consumption were recorded. The figure for mist (from an adjacent house) is included for comparison.

Table 8. Economy in base heat for cuttings 40 days (11/12/77 - 27/1/78).

Species	Method (WB & Pl) and percent rooting			
	Control	on/off	Sensor	Mist
Elaeagnus pungens 'Maculata'	58%	50%	66%	44%
Prunus aurocerasus 'Otto Luyken'	60	70	66	80
Mahonia japonica	38	57	50	57
Chamaecyparis lawsoniana 'Columnaris'	100	70	70	84
Ceanothus 'Southmead'	52	18	10	74
Ilex 'Mme Briot'	60	50	80	54
Viburnum davidii	75	95	80	90
Consumption (units per m^2)	66	60	50	93
Cost	£2.64	£2.40	£2.00	£3.72

These figures show the high cost of the mist system during the winter months. It may well suit nurserymen to use mist during the summer months, especially in warm sunny districts. Nevertheless, some figures we collected during the past month are interesting. We estimated that the mist unit was costing us 104p per square m per month in electricity consumption compared with 53p per sq m per month for a warm bench and plastic inside a general glasshouse. Insulated frames on the ground within a plastic structure were running at a cost 20p per month. The cheapness of an insulated frame inside a plastic growing house indicates that a raised bench in a general growing house is not the most economical arrangement. It is better to have a separate propagating house which does not have to be ventilated to the sáme degree as a general purpose house.

At the risk of stressing the obvious it may be well to mention the need to keep a heated bench covered all the way with plastic. Yet an operator not conscious enough of cost might well overlook this if using only part of the bench for striking cuttings.

Another consideration is the effect of reducing the period of bottom heat either at the beginning or end of the rooting period. At Kinsealy a preliminary trial was carried out during investigations on the rooting of *Chamaecyparis* (Table 9).

In this trial covering seven cultivars cuttings inserted in September rooted better without bottom heat. In October rooting was poor unless bottom heat was given, but not continuously. Better results were obtained when the cuttings were left cold for the first month. We need to do more trials on this aspect, but these first results do indicate an interesting field for investigation, perhaps in combination with different levels of moisture.

At a previous meeting (1977), Ward showed how a double tunnel (a low tunnel within a plastic structure) could be used for

Table 9. Effect of four temperature regimes on rooting of *Chamaecyparis* cuttings.

Cultivar	*Inserted*	21°C *(Continuous)*	21°C *(1st month)*	21°C (after *1 month)*	*Unheated*
'Minima Glauca'	Sept.	3	4	1	36
'Minima Glauca'	Oct.	2	1	8	3
'Tharandtensis caesia'	Sept.	6	15	17	25
'Tharandtensis caesia'	Oct.	30	40	40	2
'Erecta viridis'	Sept.	4	29	21	72
'Erecta viridis'	Oct.	7	15	70	18
'Fraseri'	Sept.	1	9	11	31
'Fraseri'	Oct.	8	23	50	35

summer and for late autumn cuttings. Is there a case for using bottom heat in a plastic structure over the winter? At Kinsealy we constructed frames as fully insulated as we could make them with polystyrene lining and placed bubble type plastic over the cuttings. Table 10 shows the results in percentage rooted.

Table 10. Cuttings in plastic house. Percent rooting. Inserted 25/10/79.

Species	Min. bottom heat 20°C	10°C	Unheated
Chamaecyparis lawsoniana 'Columnaris'	80(20)*	74(11)*	95(0)*
× *Cupressocyparis leylandii*	32(53)	20(20)	60(0)
Juniperus communis 'Hornibrookii'	3(97)	67(0)	93(2)
Pittosporum tenuifolium 'Silver Queen'	10(43)	44(15)	55(6)
Ilex 'Mme Briot'	60(5)	69(12)	69(6)
Thuja occidentalis 'Boothii'	40(60)	95(5)	73(0)
Lifted	8/4/80	19/5/80	20/5/80
Units used per 3.7 sq m	721	563	–

* Percent dead in parenthesis.

By applying the conventional base temperature of 20°C, the cuttings inserted in October were ready to lift six weeks in advance of those in the frame heated to 10°C, and the latter gave little or no speeding up of rooting, compared with the cold frame. At a cost of, say 4p per unit these six weeks cost £29 per frame (3.6 m × 1 m) or a little over 2p per cutting. Since the cuttings heated at 20°C were lifted in April, a time when there are not many cuttings to be inserted, most growers would be more interested in waiting until May when the cold frame cuttings can be lifted in advance of the summer batches of cuttings. The generally larger numbers of dead cuttings where heat was given is in line with our general experience that bottom heat is not favoura-

ble to most cuttings covered with plastic during the winter months.

To sum up: In the present anxiety to save energy we should not think of reducing heating input as the only way to reduce costs. Although investigation into temperature regimes can be rewarding, other aspects of propragation technology are important also. More research is needed to define in a more precise way the mode of action of hormones, wounding, compost moisture levels, and other factors promoting high efficiency.

LITERATURE CITED

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2. Lamb, J.G.D. 1977. Effect of two temperature regimes on rooting cuttings. *Proc. Inter. Plant Prop. Soc.* 27:35-37.

J. ANSTEY: Why does putting conifer cuttings further apart lead to better rooting?

J. LAMB: I suggest that conifer cuttings are commonly rooted at periods of the year when the light conditions are poor. They are relatively dense cuttings and they shade each other.

B. MACDONALD: Have you done any work with relation to the compression of composts?

J. LAMB: No, but in experiments on moisture levels in composts we try to keep them as equal as possible.

J. CLAYTON: In relation to water regimes what composts were you using; was it a peat/sand mix or a peat/grit mix?

J. LAMB: We used two parts moss peat to one of sand (non-limestone sand), the standard compost we used for everything except ericaceous plants, for which we use peat only.

B. RIGBY: When you combine wounding and hormone on, for instance, *Alnus* cuttings, can we assume you still only apply the Seradix at the base of the cutting, not to the extent of the wound?

J. LAMB: It was along the length of the wound; whether or not this was significant or not I don't know. We are all aware when using liquid quick-dip hormones, work at East Malling has shown that you should only dip the very base of the cutting.

PROTECTED CROPPING

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There has been a big increase in crop protection over the past few years on nurseries all over the country for both propagating and growing-on purposes. In most cases, the protection has been provided by comparatively cheap polythene clad tunnels, although many growers express a preference for glass if they could afford it. The main benefits are produced by the ability to gain better control of growth under protected conditions.

Shelter is provided to protect the plants against excesses of cold, heat, wetness, desiccation, and to a lesser extent, light. It is obvious that these factors interact; light, for instance, when provided by sunshine is normally associated with an increase in temperature but there are occasions when absence of light might be beneficial.

PROPAGATION

By giving stock plants protection there is an opportunity to obtain earlier growth, more material and an improvement in quality.

Earlier Growth. The earlier propagation can be started, the longer the growing season in the first year. This increases the chance of successful overwintering, particularly with deciduous plants such as Japanese maples, magnolias and deciduous azaleas. Such high value plants are better able to carry the cost of providing protection. An early start with propagation is not always a virtue as size and age of a cutting is also important. Work at Kinsealy proved that larger cuttings of pyracantha taken in September, ended up the following autumn bigger and better than cuttings struck in early summer. The material taken in September also flowered and berried.

More Material. Rapid growth can lead to the production of more cuttings from a mother plant but there is a risk in extending the propagating season beyond the point which allows good plants establishment before the onset of winter. Providing lighting to extend the daylength is sometimes used to prevent this problem arising.

Speeding up growth early in the year is not without risk. Soft growth is subject to frost damage and some simple form of heating might be necessary as an insurance policy. Sufficient heat to keep out frost is all that is needed. To maintain a temperature of 7°C (45°F) would use about 3½ times the amount of

fuel required to achieve 4 to 5°C (40°F) in the West Midlands from February to May.

Improvement in Quality. This does not follow automatically once protection has been provided; it can only be achieved by good management.

The climate within a structure is largely dependent on the type of cladding; growth under polythene is softer than under netting. High humidity favours development of certain diseases such as *Botrytis* and *Pestalotiopsis*. The shelter also favours rapid build up of pests like aphids and red spider. Such problems can spread rapidly within closely spaced stock plants.

Consideration must be given to the method of growing the stock. If planted permanently on the site, the area is occupied continuously and thus production costs are increased, unless the protection is mobile or temporary. There are also difficulties with plant spacing. After a year or two, more room is required for each. This can be achieved by planting fairly thickly initially and thinning as required or by planting to allow room for future development and filling in spaces with container-grown stock plants in the early years. It is more economical to grow the stock plants in containers and to provide protection only during the cutting production season than to occupy the tunnel throughout the year. Permanent and accurate labelling is essential. Growth of some subjects is rapid so adjacent cultivars should have different leaf characteristics to avoid errors when collecting propagating material.

Pruning is an important factor in maintaining health and quality. The aim should be to produce well balanced growth for propagation but to leave sufficient reserves to build up the stock for production next season. Surplus cuttings should be removed to avoid a build-up of hard straggling growths with lower production potential. When a cut is made the welfare of the stock plant should be considered. Pruning snags on stock plants are frequently the cause of die-back and other problems. Any wound makes entry of certain pathogens much easier. Routine spraying with a range of materials is necessary to avoid build-up of disease.

Good ventilation is necessary on most occasions and spring can be a difficult period. Temperatures rise rapidly when the sun shines; ventilation helps to produce more balanced growth, able to withstand low night temperatures. Shading may be needed to avoid leaf scorch. Once the crop of cuttings has been taken, steady growth should be encouraged so that the stock plants enter the winter rest period in a suitably mature state.

To provide protection is not cheap so a good yield of high

quality material is essential. The best way to deal with bread and butter lines is to have sufficient outdoor stock plants to allow large batches of selected material to be removed at the correct time. This will lead to greater crop uniformity.

New introductions to the nursery and difficult or high value plants can stand the extra costs that protection imposes. On certain sites, climbing plants respond favourably by producing earlier and more cuttings when protected from wind. They can be intensively housed and need not occupy the area for long.

By difficult plants we usually mean difficult to root or difficult to establish and grow satisfactorily on their own roots. Protection of stock plants could well be helpful in increasing the percentage rooting obtainable from cuttings. The propagator has greater control over growth but what is probably more important still are the changes that occur in the plant itself when given certain types of protection. The studies at East Malling of preetiolation leading to improved rooting of difficult fruit and ornamental plants have been noted with interest and are being followed up at various centres in collaboration with Dr. Howard. The technique of covering pruned stock plants in early spring with a framework covered in black polythene was originally tried on apple rootstock M9. When the etiolated shoots were about 50 mm long, the polythene on the north side was opened to prevent scorching. After allowing the shoots to green up they were taken as basal softwood cuttings and rooted very successfully.

With *Tilia platyphyllos* the results were not so clear cut. The system is clearly worth investigating further and a wider range of ornamental plants is being screened.

GROWING ON

There has been a large increase in the use of protection for the production of pot liners and container grown plants. Polythene clad structures have not always produced the results that were anticipated, particularly where cultural methods were not modified to suit this system. The main benefits to be obtained are fewer plant losses and faster growth.

Plant Losses. The influence of protection on pathogens has already been mentioned. Intensive production, higher temperatures and frequent irrigation, favour many pests and diseases but most plant losses are caused by other factors. Even if propagation and potting are carried out at a reasonable time, plant establishment and overwintering are not always satisfactory. The main reasons for this are temperature and water relations.

High temperatures increase the release rate of nutrients from slow-release fertilizers. A newly developing root system is unable to cope. Under conditions of protective cover no more than half

the normal rate of fertilizer should be used. Rain is excluded, therefore leaching does not occur. Late potting does not encourage active root and plant growth. A warm autumn day or two causes too high a soluble salt concentration with consequent root damage. Problems can also occur in late winter and early spring with a quick rise in daytime air temperature. The roots are not active enough in a cold ball of compost to cope with a sudden demand for water from developing shoots. Adequate ventilation will do much to prevent problems of this nature.

The unheated type of protection we are considering will not have much effect in keeping out hard frost. It will reduce considerably desiccation by cold winds. Desiccation occurs when water loss from plants is more rapid than water uptake. If it happens when leaves are present, scorched foliage results. It is an indication of localised drought conditions even though the compost may contain adequate moisture. Shading applied in time to prevent high water loss and good culture conditions to promote good root activity will prevent such occurences.

Rapid and sustained shoot growth cannot be obtained with a poor root system. If the nutrient status is right, the most frequent cause of a sluggish root system is poor aeration of compost. Efficient drainage of compost and standing ground is essential.

Faster Growth Rate. Protection will encourage this provided other conditions are satisfactory. Loss of quality will occur unless careful consideration is given to cultural details. Adequate space must be allowed for balanced growth and some trimming will be needed to produce plants of good shape. The overall picture in structures and tunnels usually looks good, but often when individual plants are taken out, the drawn, soft growth proves disappointing.

TYPES OF PROTECTION

On many sites, simple protection against wind will bring about an improvement in growth rate and quality. The addition of a roof enables protection against excessive sunshine or moisture.

The most commonly used cladding is polythene film followed by netting. Both have drawbacks but perfection cannot be achieved with a low cost tunnel.

Propagation. Many low tunnels clad with milky-polythene are in use for propagation by cuttings during the summer months. Some walk-in high tunnels are also used for year-round propagation but in this case clear polythene is preferred because of the better light transmission during autumn and winter.

Efford Experimental Horticulture Station has successfully

employed ground-level propagation beds in a double skinned polythene tunnel, the two layers of film being held apart by a low pressure air current. Bottom heat was provided to the insulated beds by electric cables. When the outside temperature fell to 1.5°C (35.5°F) the inside temperature was recorded as 8.2°C (46.8°F). The comparative minimum temperatures in structures without bottom-heat provision were 2.8°C, 3.2°C and 3.5°C, respectively, for tunnels clad with Rokolene 1728, Nicofence 31, and one with a milky white polythene roof and netting sides. The light transmission for the first three months of 1980 averaged 47.1% whilst that for tunnels clad with different nettings ranged from 47.5 to 48.3% compared with outside light intensity.

Growing Crops. Whilst the high humidity attainable under polythene film can be useful in propagation, it can create problems in rapidly growing crops, particularly during the summer months. Temperatures, too, can be uncomfortably high unless adequate ventilation and shade are provided.

Netting has certain advantages particularly under summer conditions; growth generally is more gradual and hardier. In rainy periods however, excessive wet can lead to problems. The cost of netting is between 3 and 4½ times that of a single polythene film covering. Netting is however more durable.

For protection of plants requiring shaded conditions, e.g. camellias, rhododendrons and azaleas, structures carrying netting or other windbreak materials such as plastic webbing have proved highly successful.

Young nursery stock generally requires more protection from winter rains than is given by webbing or netting. Polythene often leads to precocious growth in the spring so a compromise is needed. This is best provided by a polythene roof coming sufficiently low down the roof curve to divert the water away from netting sides. If the structure is made from metal, a wooden batten running at the correct height can be used to form a junction where polythene and netting meet. In cold or windy areas polythene "blinds" can be provided to cover the netting during adverse weather conditions. This type of structure is likely to give the grower better control of climatic conditions than any other at a reasonable price.

A reduction in plant losses and an improvement in crop quality will do much to combat increases in cost of production. Protected cropping is one way of achieving this.

J. EDMONDS: We have been using double polythene for four years now and we are getting a lift of some 7 to 8°F. In other words, if there are 7 to 8° of frost, it is frost-free inside. There are just wooden ends which we seal fairly simply by tack

hammering the polythene together.

A. CARTER: I think, John, you are drawing air in from outside. At Efford we are using inside air. I think if you draw air in from outside you are virtually creating a wind all the time at outside temperatures. We are interested in looking at it the other way — putting in the warmer air from the house. It was suggested that if we did that we might get condensation problems, in which case we would go in for fish farming between the two layers, but that hasn't happened and there have been no condensation problems.

J. EDMONDS: We drew in air from the outside because we were wary of the condensation problems but we are heating those tunnels, which is different from what you are doing.

CLONAL SELECTION IN NURSERY STOCK

A.I. CAMPBELL and R. ANNE GOODALL

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Much has been done to improve the health and quality of planting material of many horticultural crops, especially fruit and vegetables. However, much less has been done to improve the health of the wide range of trees and shrubs widely grown as ornamentals in this country. In Europe efforts made to monitor the health standard of several species have improved their quality. Nevertheless some of the stocks imported to the U.K. have been virus infected. The best known example is strawberry latent ringspot virus in *Rosa rugosa* rootstocks. Although the growth of the stock was often unaffected by the virus and showed no symptoms, many hybrid tea rose cultivars either died or produced stunted growth when budded onto infected rootstocks.

In fruit trees the importance of each virus complex differs considerably, depending on the sensitivity of the scions and the rootstocks, the severity of each strain and the number of viruses involved. The same virus can be present in a range of fruit trees but the symptoms and effects may be different in each. For example, chlorotic leaf spot virus does not cause any symptoms on apple cultivars or clonal rootstocks but it can kill many ornamental crabapples. The same virus causes ring and line patterns on pear leaves and reduces the crop, yet when it is present in hawthorn it seldom shows symptoms.

The main method for spread of viruses among crops of woody plants is by using infected propagating material. Eelworms, aphids and other vectors play a part in the spread of

hammering the polythene together.

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The main method for spread of viruses among crops of woody plants is by using infected propagating material. Eelworms, aphids and other vectors play a part in the spread of

some viruses as does pollen and seed transmission but in comparison with faulty propagation, these factors are only of minor importance.

When there were no virus-free sources of fruit tree cultivars, it was necessary to eliminate the virus by heat therapy. To do this, the plants are grown in hot air (37°C) for three to four weeks, when apical tips are taken and grafted onto seedling rootstocks and later re-tested. Once the fruit tree material has been tested for trueness-to-type and freedom from known viruses it was designated "EMLA" and released to growers through the Nuclear Stock Association (Tree Fruits).

The benefits of the scheme are difficult to quantify and differ for each cultivar but usually the EMLA clones are easier to propagate and are more uniform, they transplant more easily, and grow better with less fertilizers. The scheme is continually being improved as new cultivars are added and improved clones replace inferior ones.

IMPROVED CLONAL SELECTION IN TREES AND SHRUBS

Making healthy fruit trees available to growers, the EMLA scheme has provided healthy budwood of 20 ornamental crabapple, and almost as many ornamental cherries. Many nurserymen have noted the benefits of using these healthy clones. However, until recently there have been few attempts in the U.K. to improve the health and quality of many other woody ornamental trees and shrubs. Some Danish and Dutch research has aimed to improve the standard of a few groups of trees and shrubs and, where possible, we will compare this material with our own best clones.

Research at Long Ashton showed that viruses were present in soil or plants in many of our nurseries (see recent Annual Reports). Such prevalence suggests the need to improve the health and quality of woody ornamentals as has been done with fruit trees.

To examine the clonal variation in growth and flowering of ornamental woody plants, cuttings and buds were obtained from a number of leading nurseries in 1975. The plants uniformly raised from this material were assessed in replicated experiments over a 3-year period for ease of propagation, vigour, form, flower quality and quantity and leaf characteristics. The main findings are shown in the following tables.

Comparisons among these clones have now been made by nurserymen, and fifty plants of the best selection of four of the shrubs have been returned to the donating nursery. From these 50 plants, new stocks will be re-propagated as quickly as possible

Table 1. A comparison of tree species from several nursery sources

Cultivar	No. of sources	Characteristics
Acer platanoides 'Crimson King'	8	Variation in leaf size, colour and vigour; some material may be 'Goldsworth Purple' or 'Faasen's Black'. Most were difficult to propagate.
Crataegus crus-galli		Only one source supplied was *C. crus-galli*, the others were mostly *C prunifolia* or as yet unidentified. A graft incompatibility problem was seen in some of the material not associated with the source.
Laburnum × *watereri* 'Vossii'	6	"Fuzzy top" was present in every clone. The cause of the disease is still unknown. A vein chlorosis virus was also present in two clones and one was wrongly named.
Malus floribunda	9	Apple chlorotic leafspot virus was detected in four clones, two of which showed conspicuous symptoms on the leaves. The virus reduced the vigour One source supplied wrongly labelled material.
Prunus cerasifera 'Atropurpurea' ('Pissardii')	8	Half of the clones received were *P. cerasifera* 'Pissardii' while the others were the darker-leaved. *P cerasifera* 'Nigra'. Some sources of each were infected with prune dwarf and prunus necrotic ringspot viruses Large differences in fruiting were noted.
Prunus serrulata 'Kanzan'	9	Plants from one source were incorrectly labelled, the other clones produced good, even growth. Prune dwarf virus was found in three clones, though this has little apparent effect on vigour
Salix alba var. tristis (Syns.: *S.* × *chrysocoma* and *S. vitellina* 'Pendula')	6	All the plants were similar and all show equal susceptibility to canker *(Marssonina salicicola).*
Sorbus aria 'Lutescens'	11	All plants were very similar and none was infected with fruit tree viruses.

and made available for sale to other nurserymen. The four shrubs selected were: *Cornus alba* 'Spaethii', *Daphne burkwoodii* 'Somerset', *Forsythia* × *intermedia* 'Lynwood' and *Potentilla fruticosa* 'Tangerine'. Plants of these cultivars will be distributed with the suffix LA79 - to indicate that the plant is a Long Ashton selection and the year of release.

In *Malus floribunda* and *Prunus serrulata* 'Kanzan' the EMLA clones were judged superior to any of the material sent in for comparison and therefore no new clones were needed. In three other shrubs and trees, *Kerria japonica* 'Pleniflora', *Salix alba* var. *tristis* (Syn. *S. vitellina* 'Pendula') and *Sorbus aria* 'Lutescens' only minor differences were found and consequently no selections or releases were made. Further assessments are

being made on the other species and any improved clones will be released as soon as possible.

Table 2. A comparison of shrub species from several nursery sources

Cultivar	No. of sources	Characteristics
Berberis thunbergii 'Atropurpurea'	11	Large variations were found in ease of propagation, leaf size and habit. This cultivar is often seed propagated, accounting for many of these differences.
Ceanothus × *veitchianus*	5	None of the plants received was *C.* × *veitchianus*. The nomenclature in this genus appears confused and further sources of this plant will be examined.
Cornus alba 'Spaethii'	11	Plants from only one source were true to name, the other being the more vigorous *C.alba* 'Gouchaltii' which has a more silvery variegation than the yellow-leafed *C.alba* 'Spaethii'.
Daphne × *burkwoodii* 'Somerset'	4	Two clones flowered at both the beginning and end of the season, while the other two were less vigorous and flowered only in the spring. The two weaker clones rooted less rapidly and were probably infected with more viruses than the vigorous clones.
Forsythia × *intermedia* 'Lynwood'	11	Variations occurred in flower size and leaf form. Some of the material was other, as yet unidentified, *F.* × *intermedia* cultivars.
Kerria japonica 'Pleniflora'	10	Nine clones were similar in all aspects, while the tenth was the single-flowered, *K. japonica.*
Potentilla fruticosa 'Tangerine'	11	Two sources supplied another cultivar, probably 'Day Dawn', while a third supplied a mixture of the two cultivars. Plants from the remaining eight sources were variable in form and vigour but similar in flowering. No evidence of poor flowering clones was seen.

Cuttings and buds of a further group of trees and shrubs obtained from nurseries in 1977 are now being assessed (Table 3).

The collected clones of some species differed little but in others there were differences thought to be due to mutations, viruses or faulty nomenclature. Often more than one factor affects the quality of the clone.

The panel of nurserymen and Long Ashton staff who will assess these plants has decided that the simple statistical layout of two blocks of three plants of each source that has been used is adequate, but that assessments need to be continued for two to three years. The genetic variation and nomenclature inaccuracies have caused considerable difficulty and have required the advice of experts in particular genera.

Table 3. Preliminary comparisons of various other trees and shrubs.

Cultivar	No. of sources	Characteristics
Berberis × *stenophylla*	9	All the sources appeared similar in growth and flowering.
Cotinus coggygria 'Royal Purple'	7	Variation in leaf colour and vigour was found and we are examining further sources of this plant (see Table 5).
Cytisus × *praecox*	7	Differences were seen in flower colour but not in plant growth.
Hebe 'Autumn Glory'	11	All the sources appeared similar in growth and flowering.
Hypericum 'Hidcote'	10	Small differences in growth and flower
Philadelphus × *virginalis* 'Virginal'	10	Large variation in vigour, form and flower. The nomenclature of this plant seems confused.
Sambucus nigra 'Aurea'	7	Large variations in leaf colour and size were found and susceptibility to sunburn differed.
Spiraea × *bumalda* 'Anthony Waterer'	11	Variation in vigour and amount of variegation. One source supplied wrongly labelled material.
Tilia × *euchlora*	5	The growth from all the sources appeared similar.

Buds and cuttings of a third group of trees and shrubs from nurserymen were received in the summer of 1979 and have now been propagated (Table 4). These plants were chosen by and will be assessed with a sub-committee of the NFU/HTA joint nursery stock committee.

Table 4. Cuttings and buds propagated, summer 1979.

Cuttings	No. of Sources
Buddleia davidii 'Royal Red'	14
Elaeagnus pungens 'Maculata'	19
Hydrangea paniculata 'Grandiflora'	9
Lonicera periclymenum 'Serotina'	16
Thuja occidentalis 'Rheingold'	14
Viburnum × *burkwoodii*	16
Viburnum farreri, (syn. *V. fragrans*)	16
Weigela florida 'Variegata'	20
Buds	**No. of Sources**
Acer platanoides 'Drummondii'	8
Acer pseudoplatanus 'Worleei'	7
Prunus × *hillieri* 'Spire'	8
Robinia pseudoacacia 'Frisia'	6
Tilia platyphyllos 'Rubra'	7

Viruses are certainly important in *Buddleia* and *Hydrangea* and large differences are already developing in the establishment and growth of most of the other plants (Table 4). For example,

the variegated shrubs, *Elaeagnus pungens* 'Maculata' and *Weigela florida* 'Variegata' exist in many forms which grow at different rates. The collections of *Lonicera periclymenum* 'Serotina' and *Viburnum farreri* already differ greatly in habit, vigour and leaf shape, and are expected to differ more as the plants mature.

Because the trees take longer to mature, assessment must continue over at least four years, by which time they will need more space than shrubs.

Cuttings, buds or grafts of the species listed in Table 5 were obtained from nurseries in the summer of 1980. Some are being re-examined because we did not previously receive material from enough sources. For example, only five sources of *Ceanothus* × *veitchianus* in 1975 compared with 17 sources in 1980. This more satisfactory number reflects the increasing interest in the scheme.

Very many different species and cultivars of woody ornamentals are used by the nursery stock industry, so full assessment is likely to take many years. Since our work began in 1975, we have studied nearly fifty different species but we have completed work on only nine.

Table 5. Cuttings, buds and grafts received in 1980.

	No. of sources	
Acer platanoides 'Drummondii'	20	Being re-examined
Acer pseudoplatanus 'Worleei'	13	Being re-examined
Acer pseudoplatanus 'Leopoldii'	17	
Betula pendula 'Dalecarlica'	11	
Buddleia davidii 'Empire Blue'	9	
Ceanothus × *veitchianus*	17	Being re-examined
Cotinus coggygria 'Royal Purple'	16	Being re-examined
Crataegus crus-galli	8	Being re-examined
Crataegus oxyacantha coccinea plena 'Paul's Scarlet	8	Being re-examined
Crataegus oxyacantha punicea pleno 'Rosea Flore Pleno'	10	
Crataegus × *prunifolia*	17	
Fraxinus excelsior 'Aurea'	6	
Fraxinus excelsior 'Jaspidea'	7	
Hamamelis mollis	6	
Prunus × *hillieri* 'Spire'	15	Being re-examined
Prunus subhirtella 'Autumnalis'	16	
Pyrus salicifolia 'Pendula'	13	
Skimmia × *foremanii* (Syn. S. *japonica* 'Veitchii')	13	

FUTURE CLONAL SELECTION PROGRAMME

To hasten the programme we have welcomed other assessment centres, mainly experimental horticulture stations and horticultural colleges; together we shall try to examine over 130 spe-

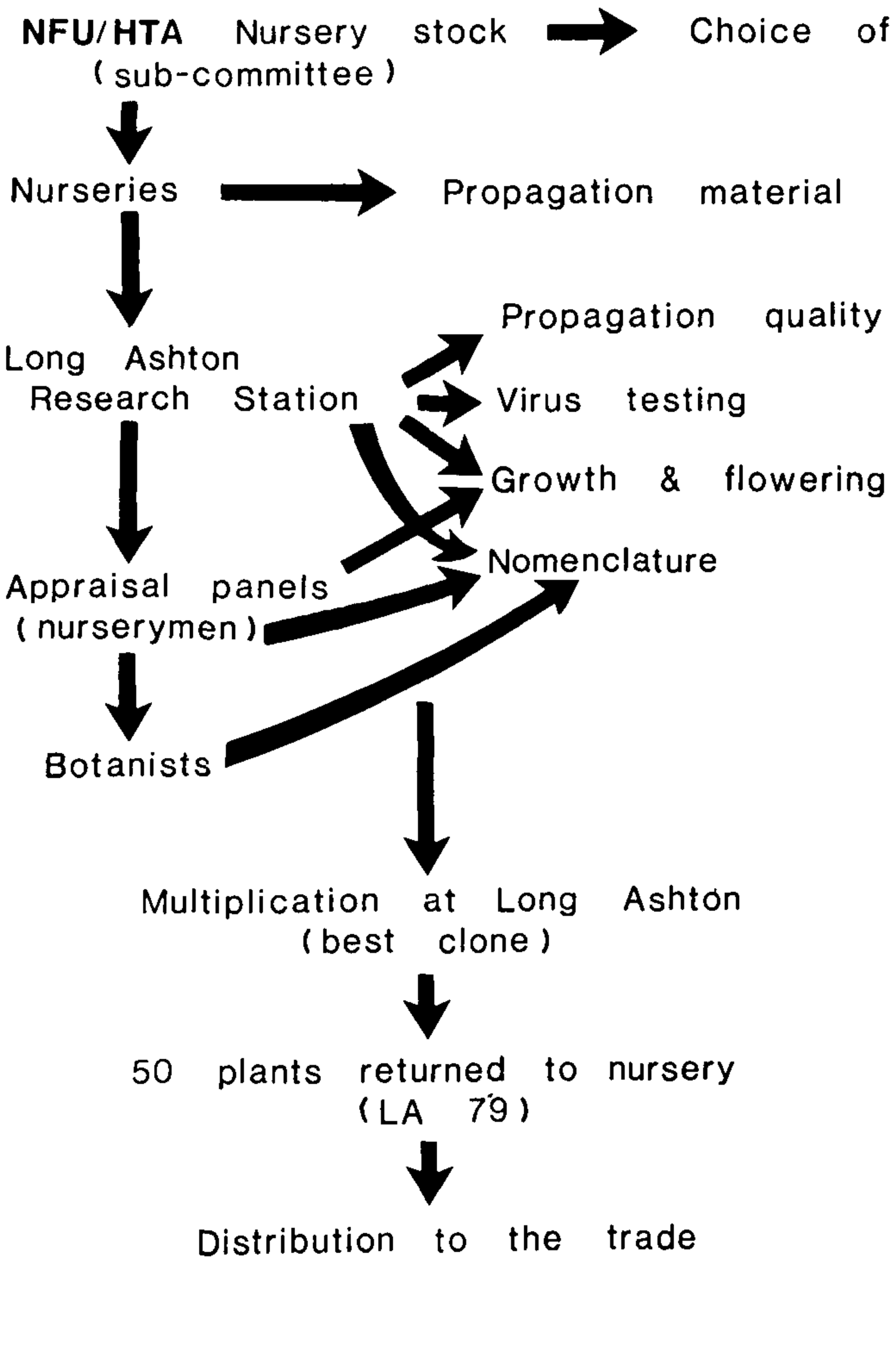

Figure 1. Long Ashton Research Station Clonal Selection Programme.

cies in the next five years. Plant assessments will remain similar to those made at Long Ashton. Standard appraisal forms which give guidance on how to score characters, such as flower colour and quantity, will be analysed once a year to determine the best plant selections to be given the LA suffix. At that time the name of the nurserymen who supplied the selected clone will be released, but the other suppliers will remain anonymous.

Plants propagated from the selected clones will gradually become available through the trade in the next few years. Two specimen plants of each selected clone will be held at Long Ashton until the new material is widely available in commerce.

Close collaboration between nurserymen, the collaborators at experimental horticultural stations and colleges and research workers will be essential for this scheme to make a large contribution to the health and quality of hardy nursery stock in the United Kingdom. Figure 1 shows how the various groups contributed to the Long Ashton Clonal Selection programme. The co-operation of the International Plant Propagators' Society, the Horticultural Education Association and the Royal Horticultural Society is gratefully acknowledged; without their help and that of the nurserymen, the clonal selection scheme which aims to improve the quality of the woody plants available in the U.K. would not make such rapid progress.

CLONAL SELECTION SCHEME

B.E. HUMPHREY

Hilliers Nurseries
Ampfield, Hants

1. **What is the Scheme?** It is a voluntary system whereby growers and other interested parties are invited to contribute to the Scheme material of certain selected plants. The material is then propagated and grown on at certain specific independent Centres. When appropriate, assessments are made by a panel of growers, advisors and specialists. The assessors, over a period, try to appraise the plants from the different sources to ascertain whether: —

a) They are true to name (untrue plants are removed from further appraisal.)
b) There is sufficient variation among the true plants to warrant further appraisal.
c) If there is sufficient variation, the Panel then tries to decide if one plant is superior to the rest when judged over a number of specified factors.

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b) There is sufficient variation among the true plants to warrant further appraisal.
c) If there is sufficient variation, the Panel then tries to decide if one plant is superior to the rest when judged over a number of specified factors.

d) If an individual plant is judged superior, it is then given an identity code L.A. (after Long Ashton who are responsible for the Scheme) and further identified by a number representing the year of identification, e.g. L.A. 79 represents those plants selected in 1979.
e) After selection, the plant is bulked up and redistributed to the trade.

2. **Aims of the Scheme.** Clonal selection is an attempt to upgrade the general quality of the nurseryman's "bloodstock". As such it may be compared with the efforts of the livestock industry.

The Scheme is an upgrading of what is already available and in general cultivation by selecting *within* a cultivar, *not* an attempt to select *between* cultivars and possibly replace one cultivar with another.

The result of the Scheme is not to *change* standard cultivars but, hopefully, upgrade them.

3. **Origin of the Scheme**

a) A.R.C. designated Long Ashton as the primary centre concerned with investigation into basic plant material being used in Hardy Nursery Stock, including its genetic potential and health status.
b) In line with similar work in fruit where several different clones of 'Cox' apple had been found, it was decided to apply similar investigations into nursery stock.
c) Work started in 1975 on a collection of common plants, some with known problems.
d) Nurserymen were shown the first results at an I.P.P.S. Meeting and Open Days.
e) In 1978, further discussion with growers took place and as a result, I was asked by Charles Notcutt — at that time, Chairman of the Joint H.T.A./N.F.U. Nursery Stock Committee — to prepare a discussion paper and try to form a Sub-Committee within the Scientific Section of the Joint Committee. I was fortunate in obtaining the agreement of a number of prominent growers and representatives of important nursery companies, together with representatives of the Advisory Service, the I.P.P.S., and individual specialists to become committee members.
f) An inaugural meeting of the new Clonal Selection Committee took place on 19th June 1979.

4. **Main functions of the Committee**

a) Advise relevant departments at Long Ashton on how the Scheme may best be run including the vital question of which plants to select for trial.

b) Provide a panel for the appraisal of the plants under trial and matters related to correct nomenclature, etc.
c) Aid Long Ashton and other bodies as appropriate in preparing Reports for publication on the results of the trial.

5. **Rules for participating growers.** Material submitted becomes the property of the Scheme *but* priority of distribution of the L.A. selection to be given to the donating grower who would *distribute it equally to other interested growers.*

Participating growers must be expected to either be prepared to bulk up from the material at Long Ashton or allow another grower to bulk up if they were not willing to do so.

The Committee reserves the right to remove distribution from a grower who was not satisfactorily distributing selected material.

The "type" plant to be held in cultivation either at Long Ashton or another establishment yet to be decided for a minimum period of several years.

Plants or "sub-clones" would be identified by the designation L.A. with numbers indicating year of identification e.g. L.A. 79.

6. **Criteria for appraisal and selection**

a) trueness to name
b) propagation characteristics
c) growth — vigour and habit
d) flower/foliage
e) fruit
f) health status

7. **Selection of plants for investigation**

Main factors taken into consideration by Committee in selection of plants:

a) economically significant
b) balance between cheap/expensive to produce plants
c) where areas of confusion in nomenclature exist
d) plants that would benefit from investigation, i.e. from *point of view of health or where there are a number of* unidentified clones.

8. **Subsequent meetings of the Committee have made the following decisions and taken the following action:**

Invited a number of other Centres to act as gathering/appraisal centres to spread the effort and speed up the process.

Drawn up a basic list of nearly 100 plant types and planned a programme of appraisal as far as 1986. This programme is not intended to be inflexible but serves as a guide to all concerned regarding work loads, forward planning, etc.

Drawn up a programme of appraisal groups (3 to 4 members of the Committee) and appraisal meetings including the design of a standard appraisal form, and carried out appraisal selections on a number of plants.

Designated four plants for L.A. status as follows:

Plant	**Source**
Daphne × 'Somerset'	— Merrist Wood
Cornus alba 'Spathei'	— Darby Bros.
Potentilla 'Tangerine'	— Coles of Leicester
Forsythia intermedia 'Lynwood'	— Wyevale

An offer of virus testing has been made from the Virology Unit at Oxford.

9. **Support from the trade**

Official support from the Joint Committee has been tremendous culminating in a vote of financial support on a significant scale.

Support from the trade in sending in plant material has generally been poor.

Don't be put off if you think your plant may be untrue, unhealthy, or inferior!

The wider the spread, the more successful the Scheme.

The Centres:

Long Ashton Research Station Long Ashton, Bristol	(Miss R.A. Goodall)
Askham Bryan Agricultural College Askham Bryan, York Y02 3PR	(Dr. Bruce Rigby)
Merrist Wood Agricultural College Worplesdon, Nr. Guildford, Surrey GU3 3PE	(John D. Shaw)
Luddington Experimental Hort. Station Stratford on Avon, Warwick CU37 9SJ	(Miss Pat Cooper)
Writtle Agricultural College Nr. Chelmsford, Essex CM1 3RR	(David Gilchrist)
Efford Experimental Hort. Station Efford, Lymington, Hant	(Miss Margaret Scott)
Brooksby Agricultural College Brooksby, Nr. Melton Mowbray LE14 2LJ	(P. MacMillan-Browse)
Wye College Near Ashford, Kent	(T.W.J. Wright)
Somerset College of Agriculture Cannington, Nr. Bridgwater TA5 2LS	(Roy Check)

Members of the Clonal Selection Committee:

D. Anderson	Darby Bros.
Edward Back	Fargo
A.R. Carter	I.P.P.S.
M. Clift	Waterer's
C. Coe	Slocock Nurseries
D. Clark	Notcutts

Miss R.A. Goodall	Long Ashton
Dr. Ian Campbell	Long Ashton
Mrs. Janet Flynn	St. Bridget Nurseries
Jack and Jillian Matthews	Matthews Fruit Trees
S. Haines	James Coles & Sons
C.R. Lancaster	
M.T. Wallis	Scotts Merriott
J. Watkins	*Wyevale Nurseries*
G.J.E. Yates	Merrist Wood
Chairman:	
B.E. Humphrey	Hillier Nurseries

G. TURNER: What provision is being made for keeping the selected clone at one centre, in order that growers may compare their existing clones with the approved clone? I am very concerned that at the moment you are introducing a Long Ashton clone which is selected from eight plants without comparing with superior plants at other nurseries.

B. HUMPHREY: I couldn't agree with you more, so send your plants in, too. The success of this scheme will depend on the degree of participation by growers and quite clearly to make a selection from two or three plants makes the whole thing nonsense. I think we have 24 clones of *Betula pendula* 'Dalecarlica' but it is hard work getting people to submit something. The industry has got to take an interest and respond over a period of time or I, for one, will lose interest. You are right that to make a selection from as few as eight clones is not ideal, and the more clones the better. As for keeping the plants, probably we would just keep the L.A. clone, as you can just imagine the problem of keeping all the others.

G. TURNER: It would be ideal if there was a L.A. clone plant of each species somewhere so that if you particularly felt your clone was better than say — *Spiraea* 'Anthony Waterer' clone plant then you could compare your plant.

B. HUMPHREY: We are planning to keep them at Long Ashton only at the moment, and if they had problems with the facilities and resources we may then decide to opt for other centres as well. We are very aware of the necessity to keep the clone for a significant period of time. The length of time would depend on the plant; if it is a shrub likely to be superceded by some superior cultivar, clearly there would be no point in keeping it forever. A marvelous job was done on selection of 'Crimson King' by East Malling, who showed that the Hadlow clone was much easier to bud than the Hillier clone and it transformed our budding take enormously.

G. YATES: I would like members to note that you must send these clones in. At other centres the response has been slight. In our own case we are waiting for cuttings of *Chaenomeles* 'Kna-

phill Seedling' but we haven't received any at all yet. The *Daphne* 'Somerset' clone received from Long Ashton is magnificent but so far only three nurseries have requested material.

M. DUNNETT, Chairman: Brian and Ian will do their bit very adequately, but if people don't respond with cuttings, and the L.A. clones are not taken up afterwards, then the scheme won't work. That, to me, would be a disaster. The scheme may have certain shortcomings, but unless it is given a try we shall never know.

COLLECTING PLANT MATERIAL IN VIRGINIA

A. BRUCE MACDONALD

Hadlow College of Agriculture and Horticulture
Hadlow, Tonbridge, Kent.

During August, 1979, my family and I were on holiday in Hampton, Virginia, situated on the south-eastern seaboard of the United States, where we stayed with James D. Ashley (I.P.P.S. Southern Region) and his wife, Beatrice. We had the privilege to meet a number of fellow I.P.P.S. members and friends which included, firstly, Robert McCartney of the Williamsburg Foundation which contains many interesting native plants. Secondly, Ken and Sandra McDonald of Le Mac Nurseries in Hampton, a foremost grower of field and container-grown azaleas. Thirdly, Charles Parkerson of Lancaster Farms in Suffolk, a quality container grower, in particular for junipers and hollies. Fourthly, Pam Harper of Robanna Shores, Seaford, a most enthusiastic plantsman who has an interesting and successful business — "The Harper Horticultural Slide Library".

When in their company one is naturally encouraged by their enthusiasm to obtain plant material. One subsequently realized that this was not plant collecting in its true word, as it was not obtained in its native habitat. However, the aim of this paper is not to discuss the merits and limitations of individual plants but to briefly relate the procedures involved in the transportation for a three to four week period of unrooted plant material often in daytime temperatures of over 32°C (90°F), together with information on their subsequent aftercare.

Procedures. Following the advice of James Ashley I purchased a large icebox from a local discount store. One person could easily handle this size container and it contained a tap to drain off water collecting at the base. The major problem I was confronted with was to prevent desiccation of the plant material under such high temperature conditions. The cuttings, on collec-

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tion, were placed and sealed in a polyethylene bag containing droplets of water. These were labelled, recorded and placed as soon as possible into a domestic refrigerator. That same day the cuttings were removed from the polyethylene bag and graded. Next, damaged or very soft and excessive stem and leaf tissue was removed. They were then relabelled and returned to the refrigerator.

When it was necessary to travel on, a large pack of crushed ice was purchased. The polyethylene bags were then pierced to allow air to escape from them — this was necessary in order that the quantity of cuttings obtained could be put into a limited space. After two to three layers of polyethylene bags had been placed inside the box, a small amount of crushed ice was evenly spread over them. Before the lid was sealed a much heavier layer of crushed ice was applied. Each day the tap at the base of the box was opened to remove excess water, which was made easier by tilting and, where possible, every third day some more crushed ice was obtained and applied over the top layer of polyethylene bags. Crushed ice could easily be obtained at stores and petrol stations. The period of cooling combined with the insulation of the ice box was very adequate for a simple technique producing results beyond one's original expectations. This, in turn, resulted in a wide range of plants being ready for subsequent propagation.

Propagation and Aftercare. It was necessary to handle the cuttings with extreme care when preparing them. Damaged tissue was first removed and then they were prepared as nodal stem cuttings. They were then immersed into a Benlate solution. A rooting hormone of 0.3% IBA in talc was applied to the softwood cuttings, while a strength of 0.8% IBA was used for the semi-hardwood cuttings. The rooting compost used was a mixture of 2 parts medium grade sphagnum peat and one part perlite. After being watered in with a fungicidal solution the trays were placed into a separate area of a shaded mist propagation unit. A few losses occurred during the first two weeks but after they had adapted to the different environment good progress was maintained. After weaning off, they were overwintered in a slightly heated structure and potted off the following April.

Some 62 different kinds of plants were successfully rooted from an original quantity of three to 20 cuttings each. Amongst these were species/cultivars of the following genera:

Azalea	*Garrya*	*Leucothoe*	*Passiflora*
Abelia	*Gordonia*	*Ligustrum*	*Santolina*
Alnus	*Hedera*	*Lyonia*	*Sebastina*
Aucuba	*Hypericum*	*Loropetalum*	*Spiraea*
Callistemon	*Illicium*	*Magnolia*	*Vaccinium*
Campsis	*Ilex*	*Osmanthus*	*Zenobia*
Cliftonia	*Lagerstromia*	*Podocarpus*	

Overall Points to Consider. As a summary the following considerations may prove helpful when collecting plant material abroad.

(i) Thoroughly check on plant health regulations. Our local Plant Health Officer, Mr. O. Hadjiphanis, at Maidstone, Kent was most helpful and gave much useful advice.

(ii) Be advised by friends on what they feel would be useful plant material to be introduced to the United Kingdom.

(iii) Keep accurate records on the nomenclature and where and when the material was collected.

(iv) Before departure to the U.K. prepare a complete list of the plant material to accompany the appropriate form for Customs at the point of entry.

(v) Take all reasonable measures to keep the cuttings turgid and prevent them from being damaged.

(vi) When preparing the cuttings on one's return do not be tempted to over-utilize the material. Their "food reserve" will have already been considerably depleted. It is better to root successfully a few cuttings and then use these young plants for future material.

(vii) Keep records on their ease of propagation, subsequent growth and development. Hardiness is an important aspect to consider.

(viii) Distribute early-on a few plants to some trusted propagator friends. This is a much safer way to ensure one's original material is not lost.

Conclusions. Not being a plantsman myself it was difficult at times to know exactly what to collect. One has to rely very much on one's own intuition on what plant may be of considerable commercial or botanical interest for the U.K. However, a point of great importance is that one should be guided by one's friends within that country on what they feel would be a useful plant for the U.K. — remembering that it is likely that a number of friends have travelled within Western Europe. Upon one's return, the situation will arise whereby one will find growing in the U.K. the same plant one has collected — but it is important to remember that one may well have a different form of it.

It is hoped this paper will spur interest in other members — even if it does create problems at the time; the rewards can be very gratifying. A sight which I shall always remember is pacing out with Robert McCartney a small area of forest and then observing the multitude of different plant material growing in its

natural habitat. It made one realise the contribution that this part of the world had made to the many plants now seen in general cultivation within the United Kingdom. In conclusion, I wish to acknowledge the advice and kindness given to us by the many I.P.P.S. members of South Virginia.

HERBACEOUS PROPAGATION

MAURICE PRICHARD
Blooms Nurseries
Diss, Norfolk

Firstly I would like to refer to heat input in the propagation of herbaceous plants. Unlike many branches of the nursery trade who have found that heated mist units have revolutionized their propagation, it must be said basically herbaceous propagation techniques have changed very little in nearly 50 years, when I first remember seeing herbaceous propagation done at our family business at Christchurch, Dorset.

Cold frames were used then for any type of propagation where protection was required, and I can honestly say this is still our only requirement. In stating this I have one reservation. Here at Blooms Nurseries during the last two years we have used a 50′×10′ polythene tunnel, fitted with mist without any form of artificial heat. This has proved successful with late-spring soft-type cuttings which wilt badly in frames, where although shaded — and the cuttings damped as often as possible — the higher temperatures proved too much. They soon lost their turgidity, finally giving only a 50% take.

Cuttings are taken and inserted in boxes and stood on each side of a central path in the polythene tunnel. As soon as sufficiently rooted, the boxes are moved to a net shaded tunnel for hardening.

Examples of plants to which I refer are:

Aster amellus cultivars
Heliopsis cultivars
Lythrum cultivars, etc.,
Euphorbia griffithii 'Fireglow'
Kirengeshoma palmata

The materials in the construction of frames have changed over the years, from my grandfather's beautifully built wooden frames complete with runners, to concrete blocks, and railway sleepers, all taking a 6′×4′ light, and finally to asbestos which we now use. These latter are built to fit a standard Dutch light. Frames can be constructed very quickly with the aid of steel or wooden stakes which are grooved to slot in the asbestos.

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As you can imagine, this has many advantages compared with a permanent structure, not forgetting costs.

Nearly half our production is carried out by division, however I am not going to cover this aspect of propagation at this time. Listed below are details of propagation methods carried out by our Herbaceous Department.

Cuttings. Our frame yard is situated on a very well drained sandy soil, with peat and coarse sand added; this makes an ideal rooting medium. After the cuttings have been cleared for planting or potting, usually by mid-summer, the frames are sterilized with Basamid. For those who can remember cutting frames of old without sterilization will appreciate what it means to be disease and weed-free.

A base fertilizer is used with a ratio of 1-1-1, with added magnesium; in fact, this is a granular fertilizer used by our farm, but is ideal in providing strong healthy cuttings.

The first batches of cuttings are started in late summer with semi-hardwoods, including lavenders, rosemary, *Santolina*, etc. Heel cuttings are taken from plants in the field and carried in polythene sacks directly to the frame and inserted without any further preparations. It is a pleasure to see two of our girls put in cuttings. In the newly-prepared frame they commence by using a 3″ wide piece of batten and drawing at least six lines with the point of the dibber, then quickly filling in with cuttings; when this is done the same procedure is repeated, and so on. This does save time compared with a few years ago when one row was put in at a time along the side of the batten.

The cutting season starts in earnest early in the new year with the first batch of basal cuttings. I should say this is where the game is won or lost, as one needs to push on to keep up to schedule before the warmer days appear; these sometimes seem to bring on everything at once. We, therefore, start to take cuttings of plants which have barely shown any new growth but have enough length of underground stem to be able to handle. *Solidago* (golden rod) would be an example. If we find that we are up to date with everything that is ready, the momentum could be kept going with a batch of *Nepeta mussinii* (catmint); these make very early growth under the cover of last season's tops. These would not normally be done until sometime in May but another job done is one less to do.

I must stress the importance in knowing the growing habits of your plants; always be checking to note progress and do not expect cuttings to be fit at the same time every year. There is really no rule of thumb; much thought has to be given so that every one of the large variety of plants we grow are properly

handled and not skimped because the weather has been allowed to catch up on us. This would end up in chaos, with not only losses but perhaps only half the required number of new plants obtained.

Root Cuttings. *Phlox paniculata* cultivars are taken in November and bedded into narrow beds in the open ground. Although it is not necessary to protect these through the winter, we have recently found a covering of Zero film has enabled us to plant a month earlier (early May), therefore producing a better plant in the autumn with the extended growing period.

Most other root cuttings are dug and prepared (cut into 3″ lengths) just before Christmas. All roots that are done at this time are fleshy and nothing less than the thickness of a pencil. This allows us to put roots into convenient sized bundles secured with an elastic band. The bundles are placed closely in rows in a frame making 'sure the tops of the roots are just below the surface. If too deep they will be doomed to rot. Examples of roots done in this way are: *Anchusa* cultivars, *Eryngium* cultivars, *Papavar orientale* cultivars, *Verbascum* cultivars, and many more.

There are some plants that are produced from roots that are better made in the early spring. These are of plants with rather thin roots that would not respond to bundling and are therefore closely lined out singly in frames. Examples of these are: *Ajuga pyramidalis, Brunnera macrophylla, Echinacea purpurea* cultivars, *Primula denticulata* cultivars, *Stokesia laevis* 'Blue Star', etc.

Seed. In my early days at Blooms Nurseries all seed was sown in boxes. Seedlings were lined out in beds until large enough to be planted. Nowadays only seed that is very small or scarce is sown in this way, the majority are sown directly into the open ground in 5′ wide raised beds which have been sterilized with Basamid. Thinly sown plants can be planted directly into the open ground which is a mighty saving in time and labour. This would really not be possible without weed-free soil.

It should be noted that peat is rotavated into the beds before sowing; also a base dressing is applied using the same fertilizer as with the cutting frames.

Seed is sown as soon as ground conditions permit in early spring. To keep our seed sowing orderly we divide beds into the three following categories:

Seed sown, planted, and sold in the same year, i.e. *Aquilegia* cultivars, *Lychnis chalcedonica, Salvia haematodes,* etc.; Seed sown and planted the following year, i.e. *Dictamnus albus* (Syn.: *D. fraxinella*), *Iris foetidissima, Platycodon,* etc.; Seed sown and

planted after two years, i.e. *Agapanthus, Hosta, Paeonia mlokosewitschii.*

Helleborus cultivars differ from the above inasmuch as the seed is sown in July/August, as soon as ripe. Sown any later, the seed would take 18 months to germinate instead of the following February after sowing.

It is very essential to have stock beds so that seed can be collected regularly, as a day too late would mean little heaps of these precious black seeds on the ground surrounding the plants, not a very nice sight when one realizes, for example, that *Helleborus* is a very sought-after plant and also very profitable.

The species raised from seed that I refer to are: *Helleborus lividus* subsp. *corsicus* (Syn.: *H. corsicus, H. foetidus, H. niger* (Christmas rose), and *H. orientalis* (Lenten rose)).

Other methods of propagation. Over the years many new ways have been found in increasing plants that have proved slow with the usual method of division. *Hosta* cultivars were a typical example until it was found that the fat, dormant, conical buds responded to having their tops cut off and then slicing with a downward cut, sometimes into four sections, each with a piece of root attached. These are lined out into narrow beds in the open ground in January and are encouraged to produce new buds; they are ideal for planting in the field in late May. Given good cultivation these make nice saleable plants by autumn. The same method of propagation has been found successful with many other plants which are slow to increase. Three genera that immediately come to mind are: *Rodgersia* cultivars, *Ranunculus aconitifolius* 'Plenus', and *Thalictrum dipterocarpum* 'Hewitt's Double'.

There is every chance that many other plants could be treated in this way; there is no doubt other methods will be tried, in time, for other slow-producing plants, perhaps using heated mist.

Bergenia cultivars are very much in demand with the ground cover age. Although these are easy to grow, increase is slow by just plain division. However by having three-year-old stock beds, plants produce their evergreen round leathery leaves on long hard stems. These stems when diced ½″ thick and thickly spread in cold frames and just covered with soil, readily produce a new shoot; when large enough they can be potted or planted in the open ground. Consequently, numbers are acquired which would never have been possible before.

There are many other unorthodox ways of producing plants, far too numerous for me to mention here. However the challenge is always there which makes it so exciting, especially with our large range of rare plants.

Comparison of various herbaceous propagation methods used over 50 years. Looking through what I have written of the present trends in herbaceous propagation and comparing it with methods I saw as a child, and what I have seen on my travels since, things have changed a great deal, not that we do things much different than our fore-fathers did; we are still using the cold frame but we have learned short cuts by being forced to take risks and, of course, the help of sterilisation, etc. has been considerable.

My earliest memories are of cold frames, which had coal ash from the local gas works spread 4″ deep to stand the kipper boxes on which were filled with stem cuttings or root cuttings. Imagine the soil mixing, time preparing the boxes and inserting the cuttings, also not forgetting the daily watering, frequent weeding, and the carrying of these heavy boxes. I often wonder why nobody thought of lining cuttings direct into the frame.

Twenty years ago I would not have dreamt of inserting lavender or rosemary cuttings without paring the heels and stripping the basal leaves. Also at this time I was not accustomed to using a dibber for herbaceous cuttings — always a sharp wornout spade cutting a neat shallow trench with the aid of a piece of batten, placing the cuttings along, filling in, treading firm, and making sure the soil was kept level to accept the next row. The time all this took compared with the shorter time today, and getting the same results.

Phlox roots used to be made in November and carefully lined out into frames. Ventilation was thoughtfully given throughout the winter until at last the lights were allowed to come off in late March when the shoots were 3″ tall and growing strongly. The growing in open ground beds as we now do with the same results makes our earlier frame efforts seem such an unnecessary chore.

As I have already explained earlier, other roots are given frame protection, but instead of lining out singly the bundles are very quickly trenched in. When the time comes to lift roots for planting the bundles are very easily lifted and boxed up ready for the planters who certainly appreciate feeding roots from the neat bundles into the planting machine.

Some of my earliest memories was of herbaceous seed sown outdoors. This seemed always a disaster with the weeds taking over before the seedlings appeared, especially with items that took months to germinate. The sowing in boxes was also a problem in unsterilised soil, so you can imagine why I get particularly excited when I see our clinical looking seed beds of today.

On the last note, I would like to point out that although we

have found no advantage in heated mist, there may be other, perhaps smaller growers, who would find the system an aid, but at what cost!

T. WOOD: Do you successfully propagate hostas and Agapanthus from seed in two years?

M. PRICHARD: Yes, if they were sold ex 9 cm pots. To obtain a saleable open-ground plant it would take three years; i.e. seed sown outdoors in April soon germinate, but are not planted into the open ground until July the following year, and are saleable in the autumn the year after. For pots, the April-sown seed is potted during April the following year, and are saleable the next autumn. There are certain cultivars you can maintain by seed, one that comes true is *Hosta ventricosa. Hosta sieboldiana* is variable but you do get some good forms.

G. YATES: Could Maurice repeat the name of the genera whose seed took two years to germinate in the seed bed?

M. PRICHARD: *Dictamus* and *Paeonia mlkosewitschii* germinate after one year, but are left a further year before being planted in open ground to make the plants saleable the following year.

B. HUMPHREY: Do the hellebores you sow now produce a root before the spring or do they just sit there taking up the warmth?

M. PRICHARD: The seed doesn't germinate until after Christmas. I can go and look during the first week in February and know that I will find *H. lividus* subsp. *corsicus* and *H. niger* started.

B. HUMPHREY: Have you ever tried warm storage first?

M. PRICHARD: No, a lot of people have but why bother? You don't want them any earlier. Just sow at the natural time they leave the plant and if you leave them just one or two weeks too late, you may have to wait another year before they come up.

BROADLEAVED TREES FROM CUTTINGS

JOHN JOBLING

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In 1958 and 1959, after a year of exploratory tests, 90 clones of poplar, *Populus*, and 25 clones of elm, *Ulmus*, were propagated from softwood cuttings in trials at the Forest Research Station, Alice Holt Lodge. The cuttings were rooted in a heated frame equipped with automatic overhead mist irrigation.

Until then, stocks of most of the clones had been produced by grafting, since propagation by other techniques, including hardwood cutting methods, had proved difficult or impossible. The trials provided hopeful signs that many trees which hitherto had not been easily raised by conventional means might be readily reproduced in future by the softwood cutting method using a mist system of watering. Thus, many trees could now be grown on their own roots for the first time, an advantage to foresters and arboriculturists.

Several species and cultivars included in the trials were then in short supply in the nursery trade or were not produced at all. Some of them, such as gray poplar, *Populus canescens*, and European aspen, *P. tremula*, are still uncommon although much sought after by conservationists, landscape architects and foresters. This paper attempts to review progress, if any, in softwood cutting methods by drawing attention to some of the work presently being carried out at Alice Holt Lodge. It is hoped that by discussing current trials and programmes of stock production for field experiments, horticultural interest in the practice of softwood cutting propagation might be stimulated.

Type of Cutting. Early trials in poplar clones of widely different botanical origin, and on elm clones artificially bred in the Netherlands or selected in hedgerows in this country, showed that the best results on both rooting and subsequent survival were obtained with sturdy and vigorous apical cuttings at least 12 cm long (6). Since then, large numbers of clones of many other tree genera have been successfully propagated using only apical cuttings. Other workers have confirmed the general use of apical cuttings.

Little research has been done on the rooting of sub-apical cuttings. However, recent trials at Alice Holt Lodge have demonstrated that many broadleaved clones can be readily propagated regardless of type of cutting. Studies being carried out to improve the production of stocks for field experiments of Hybrid Wingnut, *Pterocarya* × *rehderana*, a rare tree of immense vigour in

southern England (8), provide an interesting example The work has shown in successive seasons that both apical and sub-apical cuttings from young stock plants root equally well under mist, usually in 10 to 14 days.

Late flushing trees whose shoots grow slowly in the first part of the season and then quickly ripen, for example small-leaved lime, *Tilia cordata,* may be much more difficult to propagate from sub-apical cuttings. However, apical cuttings of this species as short as 8 to 10 cm can be easily rooted between mid-June and early August.

Cutting Origin. The highest rates of rooting are achieved with cuttings taken from young, vigorous stock plants cut back annually during the dormant season. Cuttings from plants grown close-to-hand usually root better than cuttings produced some distance away from the nursery.

Many broadleaved species and cultivars can be reproduced, however, from softwood cuttings taken from mature trees. As a consequence, large numbers of plants can often be quickly raised from material collected from specimen trees selected in the field. Stocks of more than 60 elm clones have been raised in this way during the past 20 years The method ensures the successful propagation of rare trees which, for one reason or another, cannot be reproduced from seed. The production of stocks of one of the last remaining remnants of a small-leaved lime population in south-east England has been achieved in this way.

The ability to root cuttings taken from mature trees also permits the early propagation of field specimens selected for outstanding characteristics. In 1979, seven trees of Sargent's cherry, *Prúnus sargentii,* were selected and propagated for field trials on account of their upright branching habit and attractive autumn leaf colour. At the same time, selections of goat willow, *Salix caprea,* were made for their tolerance of difficult man-made sites, and stocks were easily raised from softwood cuttings collected from trees which could not be propagated from hardwood cuttings.

If cuttings from epicormic shoots and root suckers can be found, they will often root better than cuttings taken from the crowns of the trees, though less well than cuttings from nursery stock plants. The relationship between cutting origin and rooting potential is well illustrated in gray poplar propagation (3).

Timing of cutting insertion. Most workers agree that the highest rates of rooting and the largest plants at the end of the summer are achieved with batches of cuttings inserted in the first half of the growing season. Care is needed to prevent wilting and death of very soft apical cuttings early in the season, however,

and insertion may have to be delayed until shoots on stock plants begin to ripen. The collection and preparation of cuttings of London plane, *Platanus* × *acerifolia,* in particular, must be carefully timed though, overall, stock production from softwood cuttings is generally better than that from hardwood cuttings rooted in open beds

While many easy-to-root trees, such as the common cultivars of willow and poplar, exhibit little falling-off in rooting rates in the latter part of the growing season, the plants may be small and comparatively poorly rooted at the end of the year and, after potting-up, overwintering losses may be substantial. Their survival during the winter may be only marginally superior to that of cuttings of difficult-to-root clones inserted towards the end of the season. This aspect of softwood cutting propagation requires further study. It is possible that some form of containerization for cuttings may be advantageous, permitting over-wintering indoors without having to handle the plants after root initiation.

There is insufficient evidence to prescribe optimum times for preparing and inserting softwood cuttings of related clones.

Type of Substrate. Trials started in 1979 to compare the rooting of softwood cuttings in different substrates have not been particularly informative. Some clones have had higher rates of rooting in a substrate of 75% vermiculite: 25% sphagnum peat than in other media, and cuttings in this mixture have sometimes developed a more fibrous root system which has suffered less damage during potting-up. However, only hybrid elms, *Ulmus* × *hollandica,* have benefitted significantly and, until a larger number and range of clones has shown consistent improvements both in rate of rooting and in survival and vigour after potting-up, a change from the widely used 50% coarse sand: 50% peat substrate to a vermiculite-peat rooting medium cannot be recommended

Compared with sand-peat and vermiculite-peat mixtures, substrates based on perlite and peat have usually depressed rates of rooting regardless of the perlite proportion. Roots in perlite-peat mixtures have been more brittle and liable to breakage than in other rooting media. The poorest rates of rooting have been in substrates based on bark, though further trials are probably needed before their unsuitability can be confirmed.

Substrate Temperatures. Softwood cutting propagation has been successfully carried out at substrate temperatures of 21°C (7), 21° to 24°C (2,5) and 24°C ± 3°C (1). Recently, hardwood and semi-ripe cuttings of a wide range of trees and shrubs have been satisfactorily rooted on a bench allowed to cool down for 12 hours each day, by switching off the current between 10 a.m. and 10 p.m. (4). During the night and early morning, substrate tem-

peratures were kept at 21° to 24°C.

Current trials in greenhouses at Alice Holt Lodge indicate that softwood cuttings can be adequately rooted in mid-summer on totally unheated benches. Though variations in behaviour have already been noted from clone to clone, root initiation and development overall have only been delayed by a few days due to the absence of bottom heat. Cuttings of English elm, *U. procera;* Commelin elm, *U.* × *hollandica* 'Commelin'; small leaved lime; London plane; an artificial poplar hybrid between *Populus trichocarpa* and *P. deltoides;* and an unidentified willow hybrid related to *Salix daphnoides,* have rooted satisfactorily in four weeks.

Rooting Hormones. Root initiation and development of softwood cuttings of easy-to-root clones are not significantly improved by hormone application. In the case of clones known to be difficult-to-root, hormone application may increase the speed of rooting but not the number of cuttings rooted. A trial started this season to compare the effect of different formulations and concentrations of rooting hormones on cutting survival and rate of rooting of difficult-to-root clones may throw light on the problem. So far, application of proprietary powders based on indole-3-butyric acid (IBA) and 2-naphthaleneacetic acid (NAA) have improved rooting rates more than application by the quick-dip method of the same growth regulators in solution. Perhaps, not surprisingly, some concentrated solutions of IBA and NAA quickly killed the cutting base.

The tests are being carried out on cuttings from seedling sources of sycamore maple, *Acer pseudoplatanus;* sweet chestnut, *Castanea sativa;* common ash, *Fraxinus excelsior;* common (Persian)' walnut, *Juglans regia;* and gean (sweet cherry) *Prunus avium.* These are trees which yield high quality timber suitable for the manufacture of superior furniture.

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VOICE: What are the growth rates of *Pterocarya*?

J. JOBLING: Oddly enough, I can and I cannot say. It is a tree that has just begun to receive attention for its fast rate of growth. While there are not many specimen trees about they occur in arboreta, like Westonbirt, Borde Hill, etc. They are not in plantation conditions and we haven't really observed them. We don't know what it does to begin with; maybe on some sites it could be frost tender — perhaps a bit like eucalyptus. I cannot really answer, suffice to say if you pick out of the league table of fast-growing trees it would lie in the first half dozen. Possibly up to 10′ a year in good conditions; at the beginning of its life perhaps more than that, but maybe on average 4 to 5′ per year.

D. CLARK: 1, *Pterocarya*, could you confirm species? 2, London Plane, do you have any easy rooting clone suitable for hardwood cuttings? 3, *Populus* — Moffats Clone, is it of economic importance to forestry? 4, *Nothofagus*, after a hard winter, any comments?

J. JOBLING: *Pterocarya* — we went to 4 to 5 different *P.* × *rehderana* trees; whether they were different or not, I don't know. *Pterocarya robellans* is a hybrid wing nut. It is mentioned in the Nursery Stock Manual and other books. I've been asked over the years by landscape architects how they can get *Populus canescens* for amenity planting — mostly as a replacement for elm. It is in the Commissions elms replacements leaflets for the countryside. It is a tree that grows extremely well in woodlands but can in some circumstances give a very valuable timber for lapping I think. It is suggested as an extremely good tree for heavy clay and therefore may be useful on man-made sites which are getting so much attention at the moment. We are beginning to plant it in gravel pits and domestic refuse sites. *Nothofagus* — there is a new publication that will be soon available; you may be advised to read this.

D.N. CLARK: *N. procera* does not grow well on limestone?

J. JOBLING: No.

H. SHEPHERD: East Malling has some clones of London planes grown from hardwood cuttings and has quite a lot of information on them.

AN APPROACH TO THE CONTROL OF *PHYTOPHTHORA CINNAMOMI*

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Phytophthora cinnamomi has been isolated from plants found throughout the temperate and tropical regions of the world and has been described as "one of the world's major plant killers". It has severely restricted the numbers of *Castanea* species in large areas of the USA and is largely responsible for the recession of the eucalyptus forests in Australasia. It is surprising, therefore, to find that it was first described (on cinnamon) as late as 1922. The development of this disease in the hardy nursery stock industry of Western Europe escalated after the second World War until the disease was endemic in many areas. Throughout the United Kingdom, and especially certain areas of England, the incidence of the disease early in the 1970's reached alarming proportions.

In Northern Ireland in 1974 serious losses of hardy nursery stock caused concern and a survey was carried out on all nurseries where the disease had been isolated. The results were disconcerting, indicating that as much as 10% of all nursery stock was infected. Levels well above this were recorded on three of our largest nurseries, one of which had only been established late in the 1960's.

This serious situation was approached by pooling the resources of the advisory, experimental, and scientific departments of the Dept. of Agriculture (N. Ireland). The problem was identified as one of curtailing the spread of the disease, mainly in container-grown plants. Open ground production accounted for only 20% of total plant numbers and was in decline. A decision was taken to study the epidemiology of the disease with the object of identifying possible control measures.

Although many species of *Phytophthora* were identified in the survey, the most persistent and destructive was *Phytophthora cinnamomi*. *Phytophthora cinnamomi* has both the persistent spores (chlamydospores and occasionally oospores) as well as the minute motile zoospores. It thrives in moist soils, water being essential for the transportation of the motile zoospores and for their subsequent infection of roots. The life cycle can be seen in Figure 1.

Under suitable conditions of warmth and moisture sporangia are produced on slender stalks (sporangiophores) protruding from the surface of infected roots. The precise trigger for sporangia is

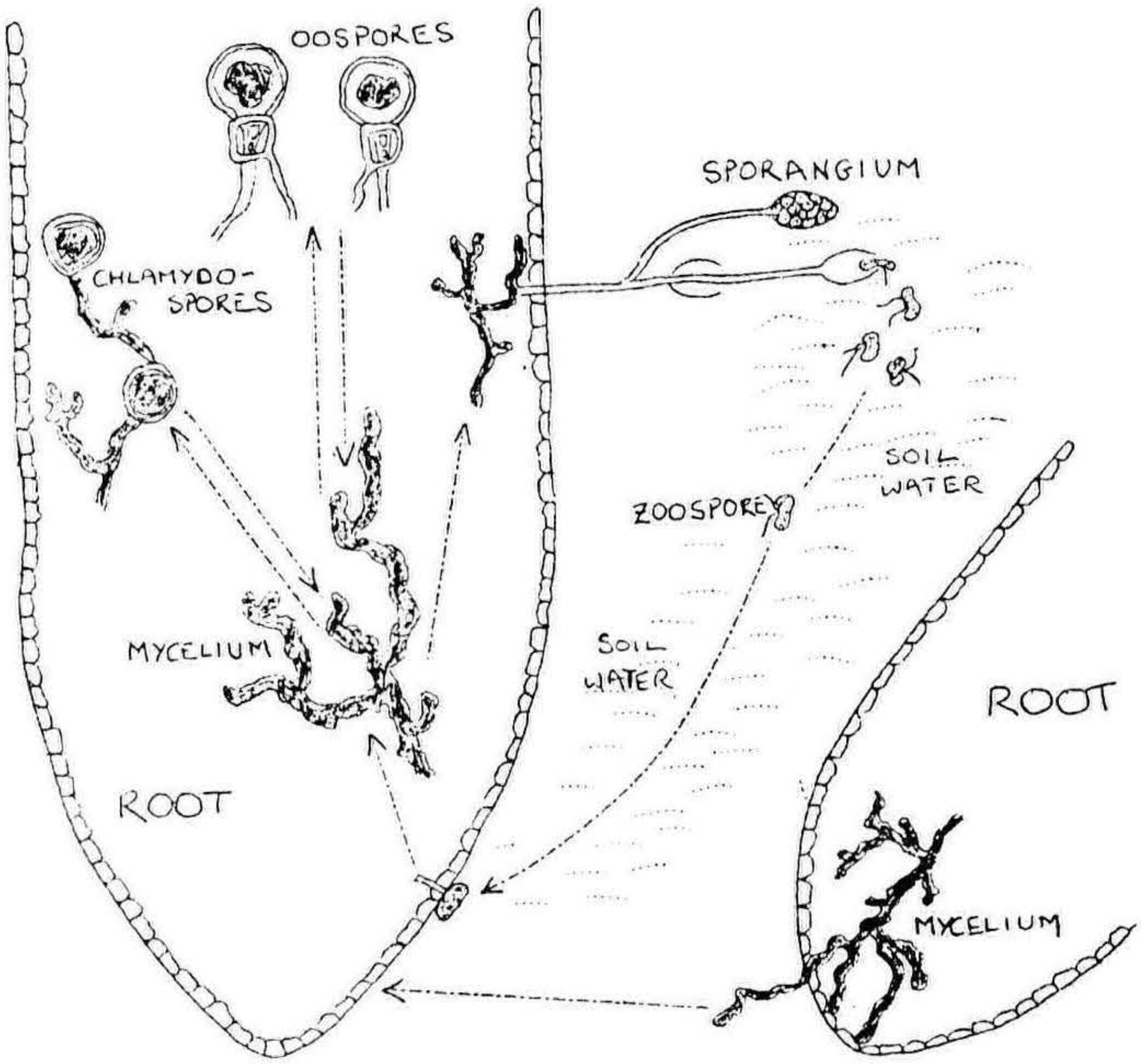

Figure 1. Life cycle of *Phytophthora cinnamomi.*

unknown but would appear to be related to biological activity (probably bacteria). These sporangia release small swimming spores (biflagellate zoospores). Although zoospores may be synchronistically released under laboratory conditions by means of a low temperature shock this probably does not occur in nature. Zoospores are chemically attracted towards plant roots but require a film of moisture as a vehicle of transport. Once formed they remain viable for only a short time and although motile are unable to travel against the flow of drainage water.

When infection has occurred the fungus spreads throughout the plant root system by means of feeding mycelium. The fungus eventually kills the plant by mechanically blocking the vessels which transport water and minerals from the roots to the above ground parts of the plant. As the pathogen is unable to live in dead tissue it must make preparation for either infection of another living plant or survival until another host plant becomes available.

In warm wet conditions infection may involve the direct penetration of adjacent roots by mycelium; or more usually by the production of further zoospores formed within a sporangium. Survival of the fungus is usually achieved in Northern Ireland by the production of chlamydospores, which can remain dormant in the dead roots for many years. Occasionally the sexual organs

(oospores) have been found. The opposite mating type of *Phytophthora cinnamomi* is not found in Northern Ireland and the oospores are produced following inducement by *Trichoderma viride* or contact with *Phytophthora cryptogea*. Both chlamydospores and oospores possess a thick protective coat which is remarkably resistant to attack by hostile agents, including toxic chemicals. These resistant resting bodies enable the fungus to survive for long periods. In the presence of suitable host roots both spore types can be stimulated to produce sporangia, mycelium, or both. Infection of roots then takes place as previously described and the life cycle continues.

Several factors are known to affect the development of *Phytophthora cinnamomi*, temperature and moisture having the greatest influence. The fungus is most active within the temperature range 20° to 30°C (68° to 86°F). In Northern Ireland these temperatures are achieved in containers from late May to the end of September. The optimum temperature for infection by motile zoospores is 25° to 26°C (77° to 79°F). It has been reported that *Phytophthora cinnamomi* makes little or no growth below 10°C (50°F) or above 34°C (93°F).

Water is an essential factor in the formation of sporangia, the transportation of zoospores, and the subsequent infection of roots. The severity of attack increases with soil moisture up to a maximum of field capacity. The optimum in soilless compost seems to be 60% to 95% moisture (the normal range for irrigated plants in containers).

All other factors (e.g. pH, conductivity), have little or no significant effect upon the development of *Phytophthora cinnamomi* but there is some evidence that high levels of surfactant added to peat as a wetting agent act as a stimulant in zoospore release.

As a result of the work carried out at the Plant Pathology Unit, methods of disease spread in order of priority were identified for Northern Ireland conditions. The most common method of spread is due to exchange of infected plant material among nurseries. Symptomless plants were found to be the largest danger. Methods of packing plants involving close contact in warm moist conditions enable rapid spread during transit. Contaminated containers and packing materials also assist in infection. All plants introduced onto a nursery must therefore be quarantined. This is best achieved by container growing on an isolated gravel bed for at least 12 months whilst their health is established by laboratory tests.

The unwitting spread of contaminated soil both on the nursery and between holdings is a major factor. If contaminated soil is left exposed then even a tractor wheel or hose pipe becomes a

vehicle of spread. Contaminated ground must be isolated with polythene or a grass sward established.

The microclimate produced under a system of intermittent mist is ideal for the development of *Phytophthora cinnamomi*. It is essential therefore that propagating materials should be free from contamination. All stock plants should be grown in isolation and checked for freedom from the disease. When in doubt the prospective material should be treated with a fungicide 14 days before cutting collection. All material is best taken from the higher parts of the stock plant. It is vitally important both during propagation and subsequent potting to maintain hygiene at a very high level to avoid contamination of the young plant material.

Disease spread within the holding is almost always from infected to healthy plants during the production cycle. This usually occurs when zoospores are released and are able to move from one container to the next via a "water bridge" (a continuous film of water). (N.B. A "water bridge" exists between adjacent plants on a sand bed.) This can happen at any stage in the production of hardy nursery stock — viz, mist unit to standing ground.

It is essential to break this "water bridge" by allowing free drainage from the base of the containers at all times. Standing areas consisting of free draining gravel are recommended as they also prevent reinfection of subsequent crops due to the fact that *Phytophthora cinnamomi* cannot persist in this medium.

Direct infection by mycelium following root contact is possible only when plants are allowed to root through into the standing ground. Plunging containers into peat thus provides not only the vital "water bridge" but also the opportunity for root contact.

Irrigation water is an ideal vehicle for infection as water is the natural environment of the zoospore. Infection can be rapid and complete (up to 90% of susceptible plants after only one application of heavily infected irrigation water). Two factors must therefore be strictly controlled. Drainage water from production areas must always be allowed uninterrupted passage from the holding to avoid contamination of the source of irrigation water. All water used for irrigation purposes should be from a clean source (mains or deep bore water is preferred).

Water splash on the surface of soil or compost during heavy rain or irrigation has been suggested as a major cause of spread. In Northern Ireland very few zoospores were found within the top 10 mm of soil. The only exception seemed to be with capillary watering, when it is feasible, that spores are carried upwards by capillary action.

The present chemical agents at the disposal of nurserymen

are limited to those capable of inhibiting mycelial growth (fungistatic) — viz, etridiazole and aluminium tris (ethyl phosphonate). There are as yet no chemicals capable of destroying the resistant resting bodies. Consequently when chemical treatment begins to become less effective or where the fungicide has failed to reach the mycelium, zoospores are released and can infect other plants and maintain spread without symptoms being seen Once treatment has been discontinued the fungus will resume attack and symptoms will soon become apparent.

When all the available information is considered it is apparent that prevention is the only practical approach. If the disease is to be controlled then it is necessary to destroy all known sources — total eradication. This in turn depends upon quick accurate diagnosis of the disease in the absence of symptoms. A method adopted by the Plant Pathology Unit for this purpose was to "bait" for the zoospore from a soil/root leachate by the use of pine needles (*Pinus radiata*) and plate this out on selected media. *Phytophthora cinnamomi* produces an easily recognizable botryose mycelium. From early May until late September results can be available in 5 days with 95% success of detection

In 1976 the Department of Agriculture for Northern Ireland offered a service to all hardy nursery stock producers for the eradication of *Phytophthora cinnamomi.* The specialist advisor when visiting a growers holding, either by direct request or during normal advisory visits, would collect samples of suspect plants. These were isolated in a sealed polythene bag for diagnosis by the Plant Pathology Unit. When *Phytophthora cinnamomi* was confirmed a representative number of soil/root samples were taken from all stock on that particular holding. Each batch of plants found to be infected was destroyed.

Subsequent advice was formulated for the particular holding and was based upon four main factors:

1. *Phytophthora cinnamomi* is seldom found more than 300 mm above soil level Cuttings taken above that height are seldom infected. No plant known to be infected should be used for propagation purposes.
2. Hygiene is of the utmost importance. Soil, sand, and containers that come into contact with the organism almost always cause a fresh outbreak.
3. Drainage water from an infected plant is the main cause of spread within the nursery. Drainage water should therefore be allowed an uninterrupted passage from the base of the pot through a gravel bed into a drainage system which discharges away from the nursery.
4 Most spread between holdings is by infected plants. All

plants should therefore be quarantined in a separate area until their health has been established. This is particularly important where plants have been treated with fungistatic chemicals. Liners bought in should be grown on a separate bed and not between batches produced on the nursery.

By the end of 1977 most of the major nurseries had been surveyed and had carried out our recommendations even when *Phytophthora cinnamomi* had not been isolated. No outbreak of the disease was recorded in the second half of 1977.

Five cases were recorded in 1978 where the infection occurred in Northern Ireland. All of these could be attributed to a disregard of our recommendations. Three outbreaks occurred on sandbeds and two as a result of a breach of quarantine precautions.

The health of our nursery stock has become well known and nurseries are increasing sales because of the very low incidence of this disease. Several nurseries requested regular surveys even though there was no suspicion of any infection as they have realized the potential value of clean stock.

It is now felt that our recommendations are sufficient to prevent any major spread within a holding and that most nurseries in Northern Ireland are reasonably free from this organism. If growers remain vigilant when importing new plant material onto their holdings the good health status of the nurseries should be maintained.

I would like to acknowledge the help given by Mr John Flack (formerly of the Department of Agriculture, Plant Pathology Division, Newforge Lane, Belfast), in the preparation of this paper

J. WARD: In reply to a question by A. Carter, we tested a 5% representative sample from the whole nursery.

A. CARTER: Five percent, and that was enough to free the nursery. This is what puzzles me. How do you manage to get rid of it?

J. WARD: When we found *Phytophthora cinnamomi* in any batch of plants we recommended that that batch of plants should be destroyed.

A. CARTER: The whole batch?

J. WARD: The whole batch. This accounted for something like 20% of the production on some nurseries.

P. WATSON: Doesn't it nevertheless mean that although you

have got the gravel bed laid down that there is no reason why the zoospores in their resting stage shouldn't still be in the sand or soil beneath the gravel?

J. WARD: We hose down the gravel bed and, provided the contaminated material is buried below the surface, the zoospores cannot come back up against the drainage water. If there is too much material we would have to renew the bed, but that has not happened yet. We recommend that where there has been contamination the most resistant species are placed on that bed the following year.

B. MORGAN. Would you say how you managed to adjust the compost that you used for this gravel base system, also the quantities of irrigation water that are required for container plants grown this way.

J WARD: Two very important points: If you are growing on gravel then you cannot use the same compost as you would use if you were on sand beds. It has to be a more open free-draining compost because during the winter months, in particular, in the lower levels of these pots the water just doesn't get away, and you get build-up. We use a 3 to 1 peat-sand mix but we use a gravel, not sand, and the gravel goes up to ¼". The easy test is that you should have more volume after you mix the sand into the peat than with peat alone. If you put sand into it you will find the volume actually decreases because it takes up the pore space and you get less volume. The granules of sand that we are putting in must be larger than pore space as we cannot block that pore space with the sand; if we do we are in trouble, so we use a sand that is a grit rather than a sand. We have a fair amount of water in Northern Ireland, not quite as much as coming down from the heavens as you may think, but we do have a fair amount of irrigation water. We haven't calculated too closely the exact requirements but the system does demand a very heavy amount of water.

D. HUSBAND: I'm interested in this swimming of spores against drainage water. To my mind if there is no precipitation then there is more danger in storage water.

J. WARD: If we do not have the precipitation then the water film will be broken as it drains away and there will be small dry areas that make it very difficult for the zoospores to actually swim up through the gravel. They don't get on very well in gravel because they have a long way to swim round each particle. It is even more difficult for it to get through broken stone and this is really why we recommend broken stone. We would like experiments to confirm this but we haven't managed to get the zoospores to come back up through the gravel.

K. LAWRENCE: How did you recommend these particular growers get rid of their infected stock?

J. WARD: The plants had to be destroyed, best by fire, destroying the container and composts as well. We covered them with a polythene tent open at the end. It takes about three weeks to dry the material to a degree where we can then burn it. We put it into very large polythene bags that are to be taken away and burnt.

DISCUSSION GROUP REPORTS
GROUP A
SUNFRAMES AND
LOW POLYTHENE TUNNEL PROPAGATION

CHAIRMAN — S.J. HAINES

The numbers attending this session showed the great interest there is in low cost propagation techniques.

On our pre-conference visit to Boulton Brothers nursery we had seen a full frame of conifers rooted under double glass, cuttings inserted in August and now ready for moving on.

Several members were using combinations of polythene and lights on their frames. Lila Dick favoured the polythene over the frame lights, thus sealing the lights and preventing pools of water accumulating on the polythene laid over the cuttings.

It was agreed that cuttings were often inserted at too great a density, and that better results were achieved by giving more space, this being particularly true of larger-leaved species such as hydrangeas. Roger Platts favoured potting these on in later summer, but care must be taken with many subjects due to overwintering problems.

John Ward and others spoke of their experience in using large tunnels as cover protection over low "inner" tunnels in which were rooted a wide range of summer cuttings.

David Whalley of the Glasshouse Crops Research Institute quoted the work of Keith Loach on light intensity and relative humidity under polythene. In lay terms their work boils down to finding the balance between the light required for photosynthesis and the need to conserve water in the cutting during the period prior to root formation. Light levels are measured in the currently favoured international units known as megajoules per square metre. In July radiation can measure up to 20 megajoules per square metre (20 MJ/m^2), but the desirable light level for rooting is between 1.5 MJ/m^2 and 3.0 MJ/m^2, so 78% shading would be

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required to reduce the daily radiation level. For those of us who rely on our judgment rather than sophisticated instruments 3 MJ/ m^2 is about the same level of radiation as occurs on a dull October day.

Ray Evison reported that he uses about 80% shade each day over his clematis cuttings. Peter Elliott said that at Coles' they use about 60% shade over clematis and also 40% shade over milky polythene-covered low tunnels during the period directly after insertion of cuttings.

The use of such degrees of shading makes the use of polythene laid directly over cuttings a far less hazardous proposition, and our visitor from Denmark, Ole Larsen, showed us slides of cuttings directly inserted under a cover of white polythene (no hoops). Once covered, cuttings inserted June/July were left to root with very little further attention Doubts over puddling on the polythene by rain and snow, pressure on the cuttings and disease control were raised but we were assured that results were excellent and costs of production very low.

Mention was made of a system used by Heinz Classen of low poly-tunnels under glass to root cotoneaster and junipers in May, water being sprayed over the tunnels to reduce air temperature. Also observed in Germany, in November, rooting of conifers in white poly-tunnels inside glasshouses without heat or hormones.

We were reminded of the double glass frame system at Boulton Bros. and wondered whether we tended to forget a well proven and inexpensive system.

Shading of polythene was discussed, use of varishade and another material tried at the Glasshouse Crops Research Institute but never manufactured.

Use of thermal screens for shading was recommended by Margaret Scott, as was a leaflet No. 24 issued by Lea Valley on the subject.

We have certainly come a long way since this subject was first discussed at our Conference in 1972, but perhaps not so far as one would have expected. It will be interesting to see what further progress can be made in these low cost propagation techniques.

DISCUSSION GROUP REPORTS
GROUP B
BENCH GRAFTING

CHAIRMAN — R. THURLOW

Subjects discussed were *Acer platanoides*, Japanese cherries, and lilacs. The chairman summarised results obtained in these genera.

Acer platanoides. Stocks were potted into 4 in. whalehides the year before grafting took place and put into frames. The following autumn they were brought inside the greenhouse to dry out before grafting. Grafting took place in January and February, a side graft being used, and tied with ½ in. polythene tape. The grafts were then placed inside a cold tunnel house. The take was about 50% in both cultivars. They will be close lined out in mid-summer following grafting.

Japanese cherries. Stocks of *Prunus avium* were potted into 4 in. whalehides the year before grafting took place and put into cold frames. They were brought inside the greenhouse the following autumn to dry out before grafting. Grafting took place in January and February, a side graft being used and tied with ½ in polythene tape, then placed inside a cold tunnel house. Five cultivars were grafted — Erecta (Amanogawa), Shidare Sakura, Hisakura, Pink Perfection and Shirofugen.

The take was good only on two cultivars — Amanogawa and Shidare Zakura, the rest being very poor; 100 stocks of each cultivar were grafted. We had to watch for black fly. Some days in late spring the tunnels became very hot and had to be shaded. Ties were taken off when a firm union had been made. The plants will be close lined out into nursery beds in mid-summer following grafting.

Lilacs. Stocks of *Syringa tomentella* were potted into 4 in. plastic pots in January and put into cold tunnel houses.

They were chip-budded in late June and put into a glasshouse, where they remained through the winter, on the house floor. In the following spring they were headed back to the bud and then fed with phostrogen until the bud had started to grow. After growth had reached 6 in. they were then stopped to allow them to bush out. The plants were potted on into 3 litre pots and placed outside in late July.

The take was over 90% of the 1,000 stocks budded.

GENERAL DISCUSSION OF GROUP REPORTS

CHAIRMAN — J. CLAYTON

J. EDMUNDS: A comment on knives and sterilisation. I don't know if Brian Howard or Ian Campbell are still here but we were talking to them afterwards about this.

I. CAMPBELL: I did say, in fact, that the majority of the viruses in woody plants would not transfer by knife.

D. CLARK: We still T-bud *Acer* 'Royal Red' and 'Goldsworth Crimson'. It may be worth just going back to why we T-bud. For a number of years we tried T and chip buds in parallel and we found we got better takes with T-budding.

J. CLAYTON: When do you do your budding?

D. CLARK: We are budding a lot later this year, as the wood is so soft; in fact, it will probably be next week (August 1). Normally we would aim to have completed the job by now. I would persevere with field propagation. I think the cost of production of 'Crimson King' from pot-grown stocks would be very high. It is interesting that we have had little comment at this conference on the cost of labour. We have talked about saving energy but I'm sure our major costs in the nursery is labour and we ought to spend more time on the cost of labour. When we went over to chip budding it took a long time for our staff to learn the technique. If your staff has been chip budding throughout and they move back to T-budding it may take a little time to gain the skills again.

I. CAMPBELL: My experience with *Acers* is that if successful with chip budding one year this is seldom repeated the following year. Perhaps there are better clones to propagate. I was not aware that there was a problem with propagating cherries. Can anyone not propagate them easily?

J. CLAYTON: We got the *Acer* budwood from Bruce and it increased our take from 15 to 20% to 55%, so the Hadlow clone is an improvement.

R. THURLOW: We were T-budding cherries up to a few years ago with reasonable results; in the last 2 or 3 years we have not had reasonable figures.

D. CLARK: We went through a bad patch with cherries and I'm looking forward to this year with EMLA top and bottom. We used seedling cherries and F12/1 and a hybrid between the two; we now use virus-free rather than virus-tested material. Thankfully we are now moving on to home-produced 'Colt'. A lot of us this year will be budding 'Colt' and with virus-free budwood it will be interesting to see if this problem goes away.

R. THURLOW: Do you use chip or T budding?

D. CLARK: In the case of cherries, we chip.

S. HAINES: There are still cultivars in nurseries that are not virus-free, like 'Tai Haku', of which we do a large number. We had virus-free 'Kwanzan' and 'Avium Plena' on virus-free 'F12/1' which were a good crop, while 'Shidare Zakura', 'Tai Haku', 'Shirofugen' were nothing like as good.

A. CARTER: Cherry problems have cropped up from time to time. It was interesting to note that Nat said that Hadlow buds are better. We bud *Acers* at a certain time and we do not pay enough attention to the state of the stock or the budwood to make sure its right. I was pleased to hear David say that this year his budding may be done next week. If your nursery has been going 30 years, you have, in fact, been making a clonal selection because if it is purely a clonal problem then over the years you have been taking wood from the good ones.

H. SHEPHERD: We have been budding Bruce's Hadlow budwood for 10 years now, and normally with chip budding we get about 80% take. I would attribute most of the variance that we get to possibly *Verticillium* because this is a great problem, particularly with *Acer platanoides.* We are doing a study of sources of 'Crimson King'. Bruce's Hadlow clone has consistently given high takes Some others have given 20%. Even though the clones look alike, there are differences in the budding take. One of the main problems in *Acer* is establishment of the stock. We irrigated our stock last year continuously; they grew actively and we found this gave us the highest bud take. We had stocks which were not irrigated; we root pruned them to slow the flow of sap but we found this was detrimental and lost about half because they were growing under stress.

1980 ROSE BOWL AWARD

The President of the G.B.&I. Region, P.A. Hutchinson, presented the Region's 1980 Rose Bowl Award to P.D.A. McMillan Browse. In outlining the recipient's outstanding contributions the President referred to his services as Hon. Treasurer (1969-72), Hon. Editor (1973-76), his terms as Vice President and Conference Organiser (1977), as President (1978) and as Past President and Committee Member (1979). As well as holder of the above offices he made contributions as Administrative Organiser for the 1969 Hadlow Conference, as lecturer in 1969, 1970, 1974, 1977, 1978 and as Discussion Group Leader in 1972 and 1979.

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THE APPLICATION OF MODERN INSTRUMENT TECHNIQUES TO HORTICULTURE

ROY RANDALL

Glasshouse Crops Research Institute
Littlehampton, Sussex

An instrument is a device that is used in performing an action — a tool or an implement. It, therefore, follows that the term instrumentation refers to the operation or arrangement of one or more instruments. Instruments of an electronic or scientific nature when used in horticulture should be considered as tools or implements and are there as such to perform or assist with a wide range of actions The question is whether we can identify those actions that can benefit from the use of modern instrumentation techniques. The actions being carried out daily within horticulture are no less frequent, diverse, or precise than those found in many other process industries. Indeed, it can be stated with some certainty that many actions related to plant growth continue for 24 hours of every day. Why should it be necessary to consider or seek new aids for the long established industry of horticulture? It is worth remembering that even the simplest tool such as the spade was evolved as a result of identifying those actions that could be assisted by the use of a suitable artifact. Are more sophisticated tools required, perhaps specifically designed for tasks found only in horticulture or, alternatively, is it possible to borrow existing techniques from other industries? Much of the instrumentation already in use within the horticultural industry has been developed primarily for other uses associated for example with medicine, meteorology and geology, whilst research and development has used every available technique. However, over the last 20 years there has been a growing need for the development of specialised equipment both for the grower and the research worker. Until fairly recently many instrument manufacturers considered that the potential sales for their products within horticulture was too small to be of great interest. Of those that did take an active interest there were some who considered that the engineering profession knew what was best for plant production and in some instances this resulted in disas-

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ter or, at the very least, great apprehension on the part of the grower when faced with similar equipment at some later date.

Today the term instrumentation is being increasingly associated with the use of sophisticated electronic devices often referred to as silicon chips, integrated circuits, or microprocessors. The news media have repeatedly drawn our attention to the predicted benefits likely to be gained from the application of such devices Can we expect that the present and future generation of electronics will radically change the potential use of instrumentation within horticulture? The evolution of the optical microscope and its early application to science brought about the need for a wide range of supporting techniques and apparatus. The generations of mechanical instruments that followed played a vital part in establishing the knowledge of today. Indeed, large numbers of mechanically based instruments are still in daily use within horticulture; for example, the mercury thermometer, bimetallic temperature recorder, and hair hygrometer The reasons for seeking new and improved techniques for instrumentation must be established in order that it may be used both efficiently and effectively. The most efficient use of such equipment should produce the maximum effect possible for the lowest effort needed to apply it. Those tools that have withstood the test of time are often those that, by due process, have been designed and constructed with simplicity but still effectively carry out the duties required of them. Such an approach is to be recommended at all times.

One possible reason for considering the use of instrumentation is for the purpose of improving the quality of plant production or at the very least to ensure that quality remains constant. The early studies relating plant growth to the environment used many of the meteorological instruments then available. The studies have intensified, the use of such equipment has continued and today monitoring and control of the plant environment is often dependent on systems using the most up-to-date electronic circuits. Such solid state circuiting is not only capable of carrying out a vast number of operations in a fraction of a second but it is also reliable, small and, in real terms, very much cheaper than the somewhat bulky equipment of even ten years ago. The skill of the mechanical instrument maker has, to a certain degree, given way to the skills of the chemist and physicist. The best instrumentation contains the skills of not only those who are concerned with its design and manufacture but above all those who are to benefit from its use.

In today's environmental instrumentation we find that the mercury in glass thermometer and mechanical thermograph are being challenged by the versatility of electronic temperature me-

ters and recorders. Temperature sensors generating electrical signals are available in size from that of a pin head to that having sufficient mass and strength that it can safely be run over by a tractor. The "throw away" age has given us the disposable temperature recorder that is used once to monitor cargo in transit, is discarded leaving behind only the chart for reference. Sensors and interface units are available at modest cost that can instantly convert the electrician's digital test meter into an electronic thermometer The manufacture of temperature sensors and associated monitoring and control equipment has become highly competitive and makes available a wide range of products directly applicable to horticulture.

The hair and sling hygrometers, together with the wet and dry bulb thermometers, are now supplemented with a range of sensors whose electrical characteristics vary directly or indirectly in relation to the relative humidity of the atmosphere in which they are placed. The development of such sensors has been lengthy and not without its problems. However over the last five years very significant progress has been made using both thick and thin film technology and it can be expected that the interest shown by major industries such as those associated with paper, textiles and food processing will result in continuous improvements being made.

The measurement of gas concentration is important, for example, in the glasshouse sector in relation to the enrichment of CO_2 levels, in the mushroom sector to detect excessive levels of CO_2, and also in fruit storage applications. The techniques employed have relied very heavily on equipment developed for the detection of hazardous gases in the mining and chemical industries Although some growers have used such methods, the infrared and conductimetric instruments referred to are primarily research tools. As might be expected the interest being shown in the subject of safety in the working environment is already encouraging the development and manufacture of simpler and cheaper instruments for this purpose. Semiconductor technology has produced a variety of new compounds that are light sensitive thus forming the basis of sensors used not only for radiation monitoring but also energy conversion. The present interest being shown in converting solar energy into electrical power will result in the availability of an even wider range of radiometers. Their small size in relation to sensitivity make them ideally suited for siting within the crop with the minimum of disturbance.

Sensors responding to soil moisture content are based on changes in electrical capacitance whilst the mercury manometer used in soil moisture tension measurements can often be replaced with a silicon strain gauge pressure transducer that pro-

duces an electrical signal. The measurement of liquid flow, conventionally accomplished with the aid of displacement piston meters, is now possible using magnetic or ultrasonic sensors clamped to outside of the pipework. Vortex shedding flowmeters are being used with flow and return temperature sensors, and a small microprocessor to determine the input of thermal energy into the buildings. The rotational speed of mechanical cup and vane anemometers is detected by photocoupled or Hall-effect, semiconductor sensors that not only reduce friction but allow remote indication and recording. The measurement of low air speeds is possible using hot wire or thermistor sensors and currently such techniques enable velocities as low as one centimetre/second to be recorded at low cost. The determination of high airflow in ductwork is carried out with the aid of orifice plates and pressure transducers having no moving parts.

A great many other factors not directly related to the plant environment, for example weight, displacement, and colour, can be sensed. These other factors are often related to productivity or efficiency and the use of instrumentation for this purpose should not be ignored. Much is being stated about the possible loss of jobs resulting from the widespread use of the silicon chip. However some form of instrumentation could well be desirable within horticulture to offset difficulties arising from the shortage of skilled labour or to relieve what in other cases might be tedious work. Automation, often electronically based, could release labour that in turn could be used for more appropriate duties. Electronic controls are more sensitive, stable and as cheap as their electromechanical equivalents. In those installations covering a large area it is very convenient for administrative reasons to concentrate the indicating or set value facilities of the instrumentation in a central position.

When carrying out multi-channel measurements it is advisable to connect each sensor in turn to one common indicator or recording instrument. If frequent readings are to be taken then it is preferable to use a multi-channel chart recorder that can be left unattended for long periods. When dealing with dissimilar sensors it is necessary to have a specially adapted recorder or alternatively process the sensor signals such that they all match one preferred range. The latter approach is made easier if battery-powered semiconductor conditioning and transmitter units are used with each sensor. In any multichannel installation it is generally necessary for a minimum of two wires to be connected from each measuring point to the recorder, but if platinum resistance thermometers are used then it may be necessary to use 3-wire or even 4-wire connections. Due to the present cost of copper the overall cable cost in such an installation might account for a large percentage of the whole.

The words computer and microprocessor conjure up visions of units of sophisticated equipment costing large sums of money. The computers of yesterday costing thousands of pounds have been shrunk into what are today no more than electronic components costing merely a few pounds. At our disposal, therefore, are components that when linked into conventional instrumentation systems can form very powerful and flexible aids to the horticultural industry. These components, integrated circuits, microprocessors, are effective both in terms of ability and cost when used to carry out relatively simple operations. As an example, the electrical signal from a solar radiation detector can be integrated against time and upon reaching a preselected value, a set amount of water can be applied to the crop. The microprocessor contains within itself a precision clock and it is, therefore, an ideal basis for that type of instrumentation requiring operations to be carried out at preset times of the day or in sequence. Its capacity and speed of operation is such that it can share its time between a great many incoming signals and commands.

In effect the microprocessor is a small computer and can, therefore, carry out mathematical calculations at rapid speed. Examples of use are for the calculation of relative humidity from wet and dry bulb sensor signals and the linearisation of thermistor characteristics. Not only can the microprocessor receive instructions and carry out subsequent calculations but it can also initiate action or secondary instructions based upon its stored memory. For the larger installation the use of a microprocessor, together with associated display or printer, could prove to be more efficient and as cheap as conventional chart recorders. For instance, a microprocessor data acquisition system could be programmed only to log at preset times of the day or when any particular parameter being monitored deviates beyond set limits. A further development is the distributed system in which a central processor is connected to a large number of smaller satellite units. Each of the satellite units is connected to the central processor via the same pair of wires, thus in a large installation only one pair of wires is installed around the site. Coded signals are transmitted along the pair of wires from the central unit to each satellite, following which the satellite uses the same pair of wires to relay back to the central unit local information received from incoming signals. The central processor may be used to transmit further instructions to the remote units following which it will transmit to the next satellite. Should a fault develop in the central processor then the satellite units may be operated quite independently as local loop indicators or controllers. Not only is such a system more flexible but significant cable costs may be saved.

If automation is desirable for the purpose of consistency, or

reduction in labour, then a measurement alone is not sufficient and measurement must be compared with a desired value and if different appropriate action is taken. In the past it was customary for manual readings (e.g. using a thermometer) to be followed by manual adjustment (e.g. using a heating valve). At that time electronic control was often unreliable and costly compared to labour costs. The modern computer enables the human input to be reduced to a minimum once the programme of operation has been established. Various parameters can be 'scanned and resultant action initiated with consistency and reliability such that optimisation of plant growth can be achieved based upon available knowledge. At least 20 sophisticated computers are in use in the glasshouse sector, each one controlling the environment in several separate areas of the nursery. Not only is temperature and humidity controlled but wind velocity and direction, ventilator position, and incidence of rain is taken into account. Reaction from those using the existing installations is very favourable and already discussions are taking place with a view to applying similar techniques to the mushroom sector.

It would appear that communication within horticulture is such that techniques used successfully in one sector are often not known by another sector. Research and development establishments are, by far, the largest users of instrumentation and perhaps, therefore, it can be argued that it is one of their duties, in conjunction with the Advisory Service, to demonstrate to the industry the full potential of all new techniques. It might be asked whether we are likely to create more problems, not less, by the application of sophisticated electronics within horticulture. Have we sufficient data and experience, it may be asked, with which we may apply and instruct these complicated pieces of equipment and will it, in turn, feed us with vast amounts of data that can only be digested by even more powerful computers? Many within the engineering profession, and it would appear to be particularly so with computer and control engineers, are somewhat puzzled to find that there is still much to be learnt about growing which is very much an art when compared to the manufacture of silicon chips. If horticulture is to benefit from other innovations such as mechanical handling, nutrient film growing, alternative sources of energy, then it is reasonably certain that new forms of instrumentation will be needed not only to apply these new techniques but also to establish facts upon which they may be developed.

Many growers are using up-to-date electronic techniques for purposes other than production. Modern surveillance and security systems scan selected operations and upon detecting a failure or significant deviation automatically transmit a prerecorded message to the grower. In some instances, temperature alarm can

be transmitted across the nursery using high frequency signals superimposed upon the normal electrical mains. A single probe inserted into the boiler flue will generate signals to a portable instrument whose digital display will show not only flue temperature and oxygen level but also boiler efficiency.

It can be seen, therefore, that modern instrumentation is a valuable aid to horticulture, particularly for the purpose of acquiring data about processes being undertaken, and to control others within very close limits. It is an aid to the establishment of new techniques, business efficiency and security. The question is whether the use of instrumentation requires in itself support that is not normally catered for within horticulture. The problem of repairs and maintenance to electronic instruments is something that must be considered. It is likely that visual inspection of some mechanical equipment will detect if a fault is present whereas in the case of semiconductor circuitry such as approach is not practical. Indeed it is likely that an electronic instrument will not fail completely but give erroneous or erratic readings. Equally it is wrong to assume that an automatic control system is performing correctly at all times. Although the development of sensors has advanced, the progress made has lagged significantly when compared to the present level of accuracy and reliability of semiconductor devices. Regular checks of sensor calibration against known physical standards is therefore recommmended. Furthermore it is likely, human nature being what it is, that instrument dials and charts will be accepted as being accurate. It is therefore essential for regular checks to be carried out on total system performance if the full benefit is to be obtained. This will mean that accurate test equipment must be made available for use by staff having sufficient technical expertise. Whilst many manufacturers provide excellent repair and maintenance facilities it is true to say that few, if any, can offer a 24-hour service. Those processes or actions that become dependent upon instrumentation must be backed, at the place of installation, with full technical data and necessary spares. Whilst the local watchmaker, may be able to rectify a fault on a thermograph it is unlikely that the local electrician will be able to repair a computer.

Biological research and development by its very nature is slow when compared to the rapid advances being made in the field of electronics Whilst this may have advantages it does raise the question of obsolescence. Providing the purpose for which equipment is purchased does not change radically then its potential life span will not be affected by the availability of updated versions. However rapid electronic development could make repair difficult and, in some cases, impossible due to the obsolescence of component parts, high labour costs, or disinterest on the part of a manufacturer. In many instances it is likely that only a

small number of identical or similar instruments will be installed at any one site and, therefore, it may be difficult for the grower to transfer less essential equipment. The practical life span of modern instrumentation may be considered shorter, even though generally more reliable, than was experienced a few years ago. As an example, the electronic part of a heating and ventilating control system might have to be changed as a result of one peripheral item being no longer available. However, there is a clear indication that there is an increasing need for good instrumentation, carefully selected and applied, within horticulture. It will not replace good growing but will prove to be a valuable tool in assisting those engaged in a precise and efficient industry.

J. GAGGINI: Is there any instrumentation to measure aeration and compression of composts?

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J. GAGGINI: Do you think it will be possible to design a simple piece of equipment to measure density?

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J. CLAYTON, Chairman: Who can one go to for advice on this modern equipment, that becomes obsolete so rapidly, especially to prevent us from spending thousands today only to find that it is obsolete tomorrow?

R. RANDALL: I would suggest you keep in close touch with A.D.A S. and N.I.A.E They are dong a lot of work on computer control and several manufacturers produce control equipment for the glasshouse market. I can also be contacted on anything I have to date.

PROPAGATION OF SHRUBS USING BLOCKING COMPOSTS[1]

DEREK C. ATTENBURROW

Horticulture Division

Fisons Limited, Levington Research Station

Levington, Ipswich

Abstract. The propagation of tree and shrub cuttings in peat blocks made from fertilized peat (Levington Blocking Compost) has been investigated. It was shown that peat blocks can offer a viable alternative rooting method for many

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species The use of peat blocks gives a significantly lower density of cuttings in the propagation house However, this early disadvantage may be balanced by the advantages of faster rooting plus a better and higher percentage establishment due to lack of root disturbance or damage Additionally, some subjects when rooted into fertilized peat blocks can be potted directly into one or two litre pots thus saving on potting and handling time The benefits of faster establishment can result in a reduced period from propagation to a saleable product compared with traditional methods

There is a requirement to reduce to a minimum the period between propagation and the production of a saleable plant. Additionally, uniformity in growth pattern and form within batches to ensure the maximum number of top quality plants is necessary.

Care over selection of cutting material and propagation technique is important for the production of well rooted cuttings. However, with the common practice of rooting in trays, if cuttings when rooted are not potted up straight away, starvation, over-crowding and root damage on transplanting can result in uneven and poor establishment.

Recognising the practical significance of the above Dendy (1) investigated the use of peat blocks made from a fertilized peat substrate (Levington Blocking Compost) for the propagation of some 33 types of trees and shrubs. Results of this work indicated that cuttings rooted well in fertilized peat blocks and that subsequent establishment was noticeably better with fewer transplant losses. In the light of these results, the use of fertilized peat blocks for propagating trees and shrubs was investigated covering a wide range of subjects at different sites and under varying conditions.

MATERIALS AND METHODS

Materials. The peat blocks in all experiments were made from Fisons Levington Blocking Compost (LBC). This is a sphagnum peat enriched with a complete fertilizer base. Typical analyses for unfertilized peat and the blocking compost before and after blocking are shown in Table 1.

Table 1. Analyses of unfertilized peat and Levington Blocking Compost before and after blocking

			*mg/l, water soluble salts, fresh compost			
	Spec Cond	pH	NH_4-N	NO_3-N	P	K
Unfertilized peat	92	4 2	6	0	2	12
Fertilized peat (LBC) unused	460	5 4	0	225	45	189
Made-up Blocks (LBC)	487	5 6	0	245	50	184

*Standard (Fisons) analytical method used by Levington Research Station.

It will be noted that the nutrient levels remain constant between the unwet fertilized peat and the wet compressed blocks.

Propagation treatments. The fertilized peat substrate (LBC) was compressed into blocks using either a hand-operated or machine blocker with a compression of around 2:1. Block size varied between 3.5 cm and 4 cm. Environmental conditions and cutting material varied according to site. Individual details are given with the results.

Potting on treatments. Methods and composts are discussed with the results.

RESULTS

Use of Fertilized Peat Blocks (LBC) for the Propagation of Shrub Cuttings, using Heat Bench. Dendy (1), using soft tip cuttings, successfully rooted 33 different subjects. Only *Erica spp* failed. Speed of rooting was similar to the traditional method using trays Thurlow (3), using soft wood cuttings, obtained variable results from 15 subjects. No comparison is available with equivalent batches of cuttings rooted by traditional methods. Of the species used, two failed completely. The first, *Cytisus sp.*, was thought to be due to the blocks being kept too wet under mist.

The second, *Elaeagnus* × *ebbingei* is inexplicable as Ward (2) reported 73% success under similar conditions, although in this case unfertilized peat blocks were used. Failure does not appear to be associated with nutrient levels since in the same experiment with Jiffy 7s, containing fertilized peat, cuttings were successfully rooted.

Rooting percentage reported by Thurlow (3) are given in Table 2.

Table 2. Percentage rooting of shrub cuttings in fertilized peat blocks (LBC) Cuttings taken from August to September 1979, Assessment made on October 24, 1979

Species/ Cultivar	Rooting Percentage	Species/ Cultivar	Rooting Percentage
Cotoneaster horizontalis	50	*Kerria japononica* 'Pleniflora'	100
Cytisus sp	0	*Lonicera* 'Baggesons Gold'	85
Elaeagnus × *ebbingei*	0	*Prunus dulcis* 'Rosaplena'	60
Escallonia sp	80	*Salix lanata*	80
Euonymus fortunei var *radicans*	90	*Symphoricarpos albus*	50
Fuchsia 'Mrs Popple'	80	*Vinca major*	80
Genista lydia	25	*Weigela* 'Florida Purple'	100
Hypericum sp			

Using a Time-Controlled Overhead Spray in an Unheated Polythene Tunnel.

At Levington Research Station softwood cuttings of ten subjects were inserted either into fertilized peat blocks (LBC) or trays containing a 70% unfertilized sphagnum peat/30% sharp grit mix. Minimum and maximum air temperatures were recorded and compost temperatures were taken at 9:00 a.m. and 2:00 p.m. daily. These showed that air temperature fluctuated between 26° and 31°C during the day, 13° and 24°C at night. The compost temperatures varied between 18°C night and 24°C day. The overhead spray was applied in one-minute bursts every 30 minutes but frequently had to be reduced due to the peat blocks becoming too wet. Results are given in Table 3.

Table 3. Percentage rooting, comparison of fertilizer peat blocks (LBC) with a peat/grit Mix. Cuttings taken August 1979, Assessment at time of potting.

Species/cultivar	Potted On	Peat Blocks	Peat/Grit
Caryopteris × clandonensis	17 9 79	70	65
Chamaecyparis pisifera 'Boulevard'	6 3 79	85	95
Cistus × hybridus (Syn C corbariensis)	22 10 79	17	5
Deutzia wilsonii	31 7.79	10	19
Escallonia 'Apple Blossom'	18 9 79	67	17
Euonymus fodumei 'Emerald 'n Gold'	27 9 79	94	94
Hebe 'Dorothy Peach'	25 9 79	50	67
Hebe salicifolia	27 11 79	96	88
Ligustrum ovalifolium 'Aureum'	24 9 79	56	7
Weigela florida	8 9 79	23	12

Deutzia wilsonii, which gave poor results, had previously rooted very successfully under mist.

Propagation of conifers in fertilized peat blocks (LBC) using heated mist bench.

Thurlow (3) tried a range of 25 subjects taken on October 25, 1979. No comparison was made with alternative substrates. Percentage rooting varied with species from nil to 100%. *Juniperus spp.* gave generally good results, other than for *J. pygmea,* which failed completed. Both *Picea spp.* failed whilst *Chamaecyparis spp.* generally gave poorer results than those experienced in the experiment discussed in 4.2.2. Increased root development and growth occurred with *Juniperus chinensis* 'Columnaris Glauca' in blocks compared with trays.

Cuttings rooted under a polythene sheet in an unheated polythene tunnel.

At Levington Research Station semi-hardwood cuttings of eight subjects were inserted either in fertilized peat blocks (LBC) or trays contaiing a 70% unfertilized sphagnum peat/30% sharp grit mix during October, 1979. The cuttings were then covered with a clear polythene sheet.

Minimum air temperatures dropped below freezing during December, January and February. The lowest temperature recorded in the peat blocks was 3.2°C. Mean air and compost temperatures are given in Figure 1.

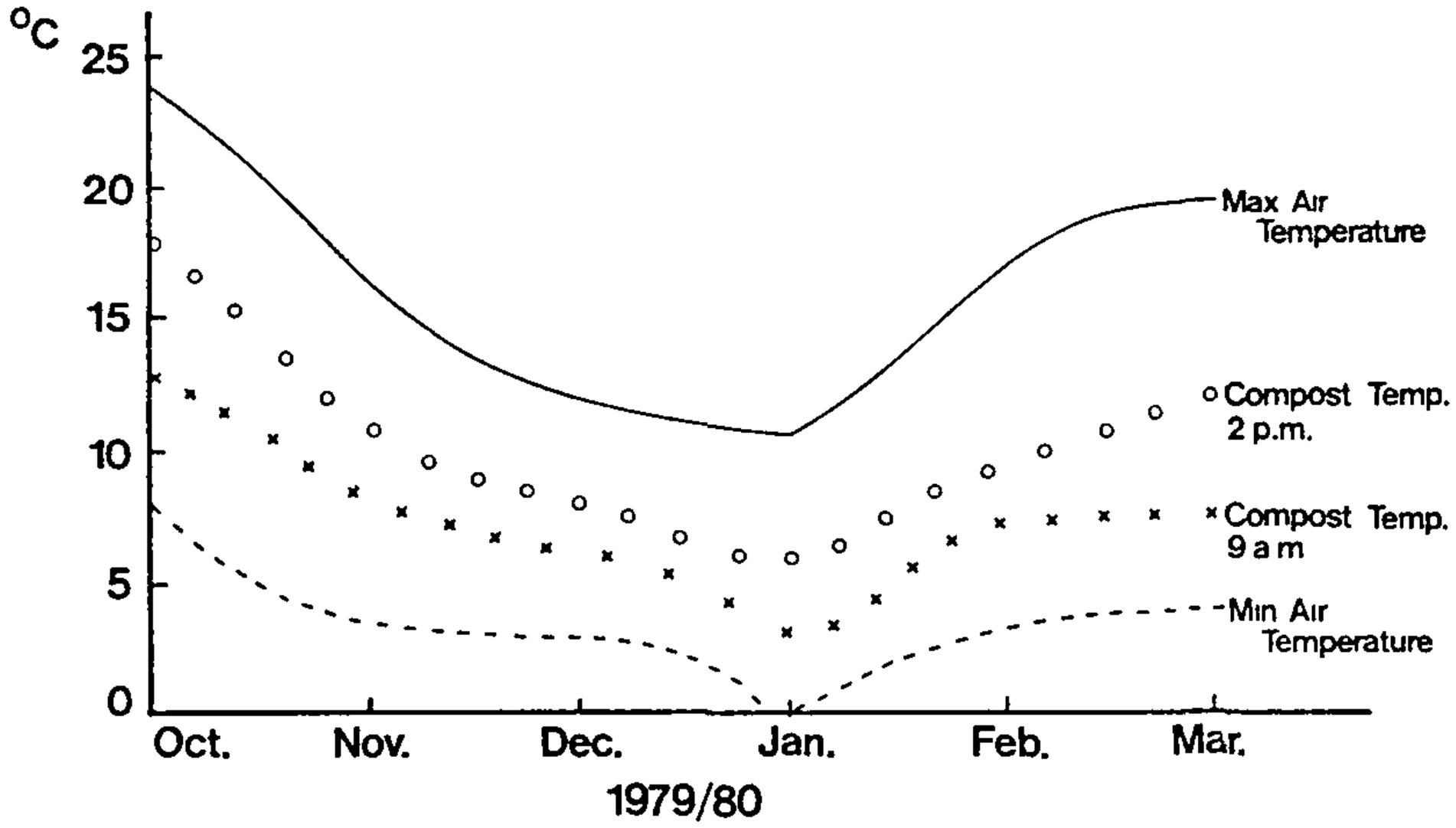

Figure 1. Maximum and minimum air and compost temperatures recorded in unheated polythene tunnel

Percentage rooting varied according to subject in the fertilized peat blocks (LBC). In the peat/grit mix rooting was negligible at the time of assessment. Results for the rooting in fertilized peat blocks are shown in Table 4.

Table 4. Percentage rooting of conifer cuttings in fertilized peat blocks (LBC) Cuttings taken October, 1979 Assessment April, 1980

Cultivar	Rooting Percentage	Cultivar	Rooting Percentage
Chamaecyparis lawsonii 'Columnaris Glauca'	84	*Chamaecyparis lawsonii* 'Erecta Viridis'	84
Chamaecyparis lawsonii 'Ellwoodii'	96	*Chamaecyparis lawsonii* 'Lanei Aurea'	34
Chamaecyparis lawsonii 'Ellwood's Gold'	97	*Chamaecyparis lawsonii* 'Pottenii'	97
		Cryptomeria japonica 'Elegans'	40
		Thuja plicata	44

Establishment at potting up; cuttings rooted in fertilized peat blocks (LBC).

Dendy (1) reported that rooted cuttings in fertilized peat blocks gave a noticeably higher percentage establishment with better early growth. The overall result was the production of saleable plants in less time than by traditional methods. Thurlow (3) potted up 16 subjects, either rooted in fertilized peat blocks (LBC) or trays, into one litre pots of a fertilized peat/sand mix

(Levington Compost Universal). Early establishment and growth were significantly better for cuttings propagated in fertilized peat blocks, as is illustrated in Figure 2.

Figure 2. Comparison of establishment for cuttings rooted in fertilized peat blocks (LBC) or trays. *Kerria japonica* 'Pleniflora' cuttings taken August 9, 1979, potted October 21, 1979, photo April 14, 1980. Appearance of plants 23 weeks after potting-up. *Left:* Rooted in fertilized peat blocks (LBC). *Right:* Rooted in trays.

Potting-on of cuttings rooted in fertilized peat blocks (LBC).

Optimum pot size (compost volume) for potting up cuttings rooted in fertilized peat blocks (LBC) were investigated at Levington Research Station. Six subjects rooted in 3.8 cm peat blocks were potted into 0.3, 1.0 or 2.0 litre pots containing a fertilized peat mix (Levington Container Compost). Those potted into the two smaller pot sizes were transferred to two litre pots as growth demanded.

Viburnum tinus, Prunus laurocerasus 'Rotundifolia', *Pyracantha* 'Mohave' and *Cotoneaster* 'Red Flare' showed no adverse affects from being potted directly into 2 litre pots. *Prunus laurocerasus* 'Otto Luyken' and *Berberis julianiae* established better in the 0.3 litre pots. This may have been due to these two species being weaker rooted and the lack of a weaning period between the propagation tunnel and being stood outside.

Use of fertilized peat blocks (LBC) for growing-on rooted cuttings.

At. G. Jones Ltd., rooted cuttings of three subjects were either transplanted into fertilized peat blocks (LBC) (125 c.c.) or traditional pots of compost (150 c.c.). Establishment in the fertilized peat blocks (LBC) was excellent and despite the smaller volume of compost the cuttings in these blocks had noticeably increased vigour compared to the traditional method.

CONCLUSIONS

Fertilized peat blocks can be used for the successful propagation of some tree and shrub species but environmental control needs to be investigated to obtain the best results.

The lack of root disturbance and damage with plants raised in fertilized peat blocks (LBC) improves establishment and early growth at potting on.

The disadvantages of the lower density of cuttings in the propagating house may be balanced by fewer potting stages and a shorter period to produce a saleable plant.

The use of fertilized peat blocks (LBC) for growing on of rooted cuttings offers better early growth and the saving of at least one pot stage, resulting in economy of compost used.

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CURRENT ASPECTS OF COMMERCIAL MICROPROPAGATION

MARTIN J. STOKES

Twyford Laboratories Limited
Baltonsborough, Glastonbury, Somerset

The Location of Micropropagation Laboratories. Commercial micropropagation units that have arisen during the last ten years have developed either in association with or in close proximity to sites of academic research in the plant tissue culture

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field. This is no accident. The successful application of new technologies requires continual access to research facilities and information exchange (Figure 1). Twyford Laboratories is an exception to this only in that it provides such facilities within the company to stimulate further developments in the micropropagation and disease indexing fields.

On a worldwide basis the principal micropropagation units are found in close proximity to Pieriks' laboratory in The Netherlands, to that of Boxus in Belgium, the late Professor Morel, Beauchesne, Tran Than Van and Nitsch in France, Zuccherelli and Rosati in Italy, and Murashige in the United States. These units have naturally concentrated on crops of local or national importance — lilies and gerberas (11) in The Netherlands, foliage ornamentals (9) and orchids (5) in the U.S.A., fruit tree rootstocks (14) and strawberries (3) in Italy and Belgium, and orchids (10), gerberas and strawberries in France.

The expertise for the micropropagation of these crops is often isolated in these areas and growers from elsewhere may be unaware of the current propagation capabilities for a particular genus.

Tropical crops grown in their own environment have received scant attention with the exception of *Elaeis* (8) and *Ananas* (13) reflecting more the lack of local tissue culture laboratories than the value of the crop. In contrast, tropical ornamentals, important in the temperate nursery industry, provide the most important genera for tissue culture laboratories in both variety and total numbers of plants.

Principal Genera Involved. Genera that have been micropropagated, sold in at least four figure quantities and judged to have been a profitable undertaking are listed in Table 1, in chronological order.

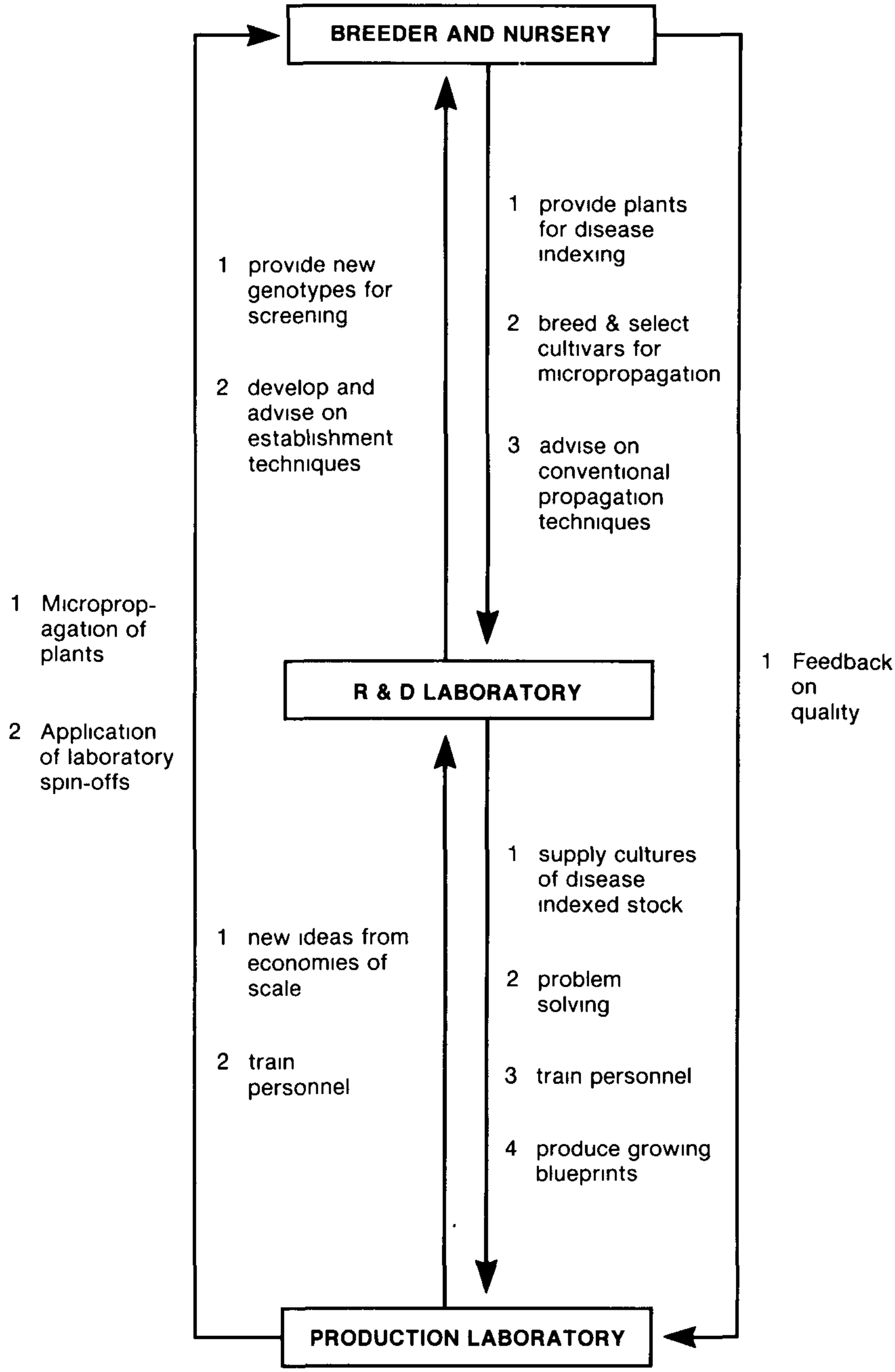

Figure 1. The interrelationships between nurseries and research and production laboratories for micropropagation

Table 1: Principal genera to which micropropagation has been successfully applied on a commercial basis, presented chronologically

FAMILY	Genera 1960	1965	1970	1975	1977	1980
ORCHIDACEAE	*Cymbidium*	*Cattleya*	*Phalaenopsis* *Dendrobium* *Vanda* *Odontoglossum*			
IRIDACEAE			*Freesia*	*Gladiolus*		
LILIACEAE			*Lilium*	*Asparagus* *Dracaena* *Allium* *Hemerocallis*	*Cordyline*	
AMARYLLIDACEAE			*Nerine*	*Alstroemeria*		*Narcissus* *Haemanthus*
ROSACEAE			*Fragaria*			*Malus* *Prunus*
FERNS			*Nephrolepis*	*Platycerium* *Davallia* *Pteris*		
COMPOSITAE			*Gerbera* *Chrysanthemum*			

FAMILY	Genera 1960	1965	1970	1975	1977	1980
ARACEAE				*Anthurium*	*Dieffenbachia* *Spathiphyllum* *Syngonium*	*Philodendron* *Alocasia*
GERANIACEAE				*Pelargonium*		
GESNERIACEAE				*Saintpaulia*		
BEGONIACEAE					*Begonia*	
MORACEAE					*Ficus*	
CRUCIFERAE					*Brassica*	
BUXACEAE						*Simmondsia*
ERICACEAE						*Rhododendron*
SOLANACEAE						*Solanum*
PALMAE						*Elaeis*
BROMELIACEAE		*Ananas*			*Cryptanthus* *Aechmea*	
ARALIACEAE					*Tupidanthus*	

Table 2. The advantages of micropropagation as applied to those genera listed in Table 1

1	Disease indexing for the production of healthy stock	*Pelargonium, Dieffenbachia, Gladiolus, Lilium, Narcissus, Fragaria, Chrysanthemum, Solanum, Cymbidium, Cattleya*
2	Rapid propagation of parent lines for F, hybrid seed production	*Brassica Beta*
3	Vegetative propagation of plants on a commercial scale that was hitherto impratical	*Anthurium, Cymbidium, Cattleya, Phalaenopsis, Dendrobium, Vanda, Odontoglossum, Alocasia, Elaeis, Nerine, Haemanthus*
4	Acceleration over conventional systems	*Lilium, Gerbera, Fragaria, Philodendron, Alstroemeria, Cordyline Dracaena, Malus, Prunus, Allium, Spathiphyllum, Syngonium, Saintpaulia, Nephrolepis, Hemerocallis, Asparagus, Tupidanthus, Begonia, Ficus, Simmondsia, Rhododendron*
5	Replacement of sexual propagation methods	*Ananas, Cryptanthus, Aechmea, Davallia, Platycerium, Pteris*
6	Rapid propagation of new hybrids	Begonia, Lilium, Gladiolus, *Freesia, Cymbidium, Cattleya, Phalanenopsis, Dendrobium, Vanda, Odontoglossum, Nerine, etc*

Table 3. Genera from which more than a million plants have been micropropagated for commerce

Nephrolepis	*Cymbidium*
Fragaria	*Anthurium*
Gerbera	*Philodendron*
Lilium	

Since I last talked to the Society in 1974 (12) the range of genera within these criteria has expanded rapidly with the result that tissue culture methods should now always be considered as an alternative option to conventional propagation.

Families of monocotyledons have provided the majority of genera that have been successfully propagated to date; principally the Orchidaceae, Bromeliaceae, Amaryllidaceae, Liliaceae, Araceae and Iridaceae. Genera that are easily propagated by conventional means exhibit a similar trait in tissue culture. Post graduate studies that have presented projections for the propagation of one million plus plants in a matter of months are concentrated on those families where success is more likely within the usually limited time allocated to specific projects Those genera that are more difficult to propagate often have to wait until the

pressures of commerce are applied. *Simmondsia* (1), *Phoenix* (7), *Picea* (4), *Pinus* (4), *Pseudotsuga* (2), *Eucalyptus* (6), *Elaesis* (8), and *Cocos* (7) are all genera to which these pressures are now being applied. *Elaeis, Malus* and *Prunus* are the first of many plantation crops to be produced successfully via the application of tissue culture propagation techniques. Although the benefits from these projects will not be realised for 5 to 50 years they will produce the major financial returns from micropropagation.

Development Costs. The high cost of independently initiating and developing a micropropagation system for a new cultivar or genus requires the subject to fulfill one of three criteria: —

1) high volume market demand
2) high market value of individual plants
3) co-ordination of demand and supply for a group of customers.

Commercial laboratories are unlikely to accept plants for propagation unless they are convinced both of the market and the likelihood of success.

Market demands may change, during the one to two year laboratory production stage and therefore 'a finger to the wind' is advisable.

Figure 2 illustrates the high proportion of costs attributed to labour, 75 to 85%. Growing room and material costs both vary from 5 to 15% of the total production cost. However, within all three categories of labour, growing room and materials, there is little variation in the allocation of costs for a wide range of genera. Policy on the allocation of overheads within different institutions may well affect these percentages. Mechanisation and automation of the preparation of growing containers only begins to justify investment when the production of these reaches the 5 to 10,000 per week quantity. The preparation and grading of microcuttings is a skilled task and is likely to be automated only if many millions of plants are required of one cultivar and a high wastage level is acceptable.

To reduce growing room costs, hygienic glasshouse environments will be increasingly employed to root and establish cuttings produced *in vitro*. The high cost of agar would thus be eliminated and the rooted plant would not be subjected to "transplant shock" on removal from the growing room to be potted-on in the glasshouse.

Health Status. The professional propagator should always be aware of the health status of his product. The environment provided for the growth of plant tissue cultures is frequently optimal for plant pathogens and saphrophytes. Unless specific precautions are introduced into the culture system the micropropagated plants may emerge with a microflora more damaging than when they entered.

Figure 2. Production costs in labour, materials, and facilities for micropropagation of several genera. Percentage of total costs.

Disinfection and disease indexing. The implementation of disinfecting and indexing procedures and monitoring of the health status of tissue cultures may be categorised thus:

1) Disinfection procedures

2) Disease indexing

3) Maintenance of the indexed and aseptic state.

Disinfection procedures commence with an incubation period under low relative humidity but otherwise optimal growth conditions to reduce the surface microflora. This should be followed by a combination of chemical, vacuum or agitation treatments of the explant, be it bud, leaf, stem or root, to complete stage one. The disinfection should be checked by culturing tissue from each explant on media that will support the growth of a comprehensive range of bacteria and fungi.

Specific pathogens may be detected by culturing tissue on defined nutrient media. To eliminate these and produce disease-indexed tissue skilled culture work is necessary, followed by regular monitoring of the status of the tissue.

Virus indexing may involve any or several of the techniques of chemo- or thermo-therapy, and testing by use of electron microscopy, serology or indicator plant tests.

To maintain the "indexed" state of the culture re-infection from other plant material via insufficiently sterilised instruments must be prevented. Dipping the handling instruments in alcohol and igniting the solvent provides insufficient heat to sterilise. A longer exposure to a hot flame is required or immersion in a chemical sterilant.

The ubiquitous *Bacillus subtilis* is a frequent contaminant of tissue cultures. Growth of the bacillus appears to be inhibited by cytokinin compounds and the extent of contamination may only be revealed when these compounds are omitted from the medium at the root induction stage. Such high levels of contamination as may then appear often inhibit root growth and reduce establishment success, particularly when plants may be in transit for several days. Considerable attention to sterilisation techniques and working procedures of operators is required to maintain control of this problem. Training in the detection of decreased vigour, stunted root growth or the characteristic appearance of the bacillus colony as it penetrates the nutrient medium from the plant, is vital in order that these cultures are destroyed to prevent the entire stock from becoming contaminated.

Certification schemes and international exchange. The U.K. Ministry of Agriculture is currently introducing a scheme for the inspection and certification of disease indexed stock of tissue culture origin. This will enable its integration into the certifica-

tion schemes for "S.S." material that already exists. Organisations wishing to enter the scheme will require written prior approval from the Ministry of Agriculture of the culture method used, including specification of the number of subcultures to which the tissue has been subjected, and the hygiene in the laboratories and glasshouses.

Disease-indexed tissue cultures provide ideal plant material for international exchange. Evidence of constant monitoring of the health status of cultures combined with an effective phyto-sanitary inspection service should enable many of the entry and quarantine restrictions imposed between states to be overcome.

As there is now an international source list of virus-tested fruit tree material produced by Long Ashton Research Station, Bristol, England; so we look forward to similar lists of hardy nursery stock and perhaps ornamentals in the future. Exchange of tissue cultured material could occur independently of season and a tissue bank, maintained under the correct conditions, would require little attention and provide effective isolation from disease.

In terms of clonal uniformity, quality of product, and health status, those concerned with micropropagation should always aim to produce plants of the highest quality.

Problems Encountered by the Micropropagation Laboratory.

Juvenility. Successful initiation of *in vitro* cultures is inversely proportional to the age and state of lignification of the tissue and can also be influenced by season. Juvenile tissue should always be sought for propagation Vernalization may be necessary to break dormancy. Disinfected material of herbaceous origin may be more readily induced, with the application of cytokinins, to form juvenile tissue than that of woody plant material.

Cultures from woody plants are most successfully initiated during the early stages of the active growth period. At other seasons phytotron facilities may be required to induce growth. Juvenility in coniferous species has been induced by grafting shoots from mature trees on to seedlings of the same species Tissue is later selected for culture once the graft has united and the scion exhibits more juvenile characters. The parameters by which forest and plantation trees are selected are only exhibited in the mature plant from which tissue cultures are often difficult to initiate. A repeatable method of inducing juvenility is a necessary precursor of the micropropagation of many tree crops.

Seasonal variation. Most horticultural crops in temperate areas are grown under seasonal systems with which the tissue culture propagator is required to co-ordinate. This results in a

seasonal imbalance of work in the laboratory and consequently loss of efficiency and increasing costs.

Development from culture initiation to delivery to customer may take one to two years and skilled forward balancing of orders is essential.

In vitro environment. Plant tissue grown *in vitro* is highly susceptible to variations in environmental conditions. Light, in terms of intensity, wave-length and photoperiod ranges is less critical than temperature. Temperatures, even within the limited range of 21° to 27°C, can limit growth. *Alocasia* and *Anthurium* exhibit reduced growth rates at temperatures above 25°C whilst optimum rates are obtained from *Lilium* at 21°C, and rooting of *Malus* and *Prunus* rootstocks at 27°C.

The hormonal constituents of the medium may be varied to control the morphology of the tissue at each stage in its production and it is these, frequently applied in levels of <1 ppm, that require the closest monitoring of all the medium constituents. Charcoal, sugar source, and total nutrient levels are other significant variables.

Some genera exhibit reduced growth rates when grown in certain plastic containers, compared with glass. Composition of the growing container is a factor to be considered in its selection along with shape for efficient use of growing room space, recycling capability, and ease of handling.

Production blueprints may be written for individual genera or clones. Considerable flexibility should be allowed for new clones. Delays in subculturing tissue of familiar clones may initiate unforeseen changes in morphology which could jeopardise production schedules.

Packing and transport. The plant produced from the *in vitro* environment is a challenging subject for those responsible for its packing and transport. In-transit handling methods may damage plants shipped in agar. Quality can be improved and freight costs reduced by despatching plants bare-root, packed in enclosed containers to prevent wilting. Removal from the growing container, washing, grading and packing should be carried out swiftly. Accurate labelling, particularly of disease-indexed stock, is necessary at this stage and should be carried through to the nursery. Transport to the growing area must be as swift as possible — within 3 days. To reduce temperature variance to a minimum, insulated packaging is essential with a specified temperature range, whether high or low, printed on the outside of the carton.

Plant establishment. The field or glasshouse establishment of plants produced from tissue cultures is a skill of which there are currently insufficient practitioners. To improve understanding of

this skill consideration should be given to including training in the handling and establishment of micropropagated plants in the syllabus of plant propagation courses.

The plants arrive at the potting bench from an environment which provided a 100% relative humidity and "balanced" temperature, light, and nutrient supplies. The emphasis should be on minimising checks to growth that may, in genera such as *Malus* and *Prunus*, lead to the onset of dormancy. Leaf turgidity must be maintained during the potting process. This "soft" plant, which will frequently have a residue of agar medium amongst the roots, and that may contain sugars, provides an ideal subject for attack by pathogens and a programme of preventative pesticide treatment must be implemented immediately the plants are potted. Micropropagated plants will only perform well if the highest standards of hygiene, including the sterilisation of compost, pots and benchwork, and cultural practice are observed.

The Future. The market value of the young plant dictates the feasibility of micropropagation. The technique is often in direct competition with conventional methods as in *Lilium, Ficus, Gerbera,* and *Prunus* rootstocks. However, the independence of seasonal supply, the propagation of plants for which there was no previous practical method, disease indexing, and clonal uniformity all combine to increase the value of this technique beyond its conventional competitor.

The barrier that propagation once presented to the introduction of commercial cultivation of many cultivars is gradually lifting as micropropagation is more widely applied Indeed ease of propagation by tissue culture may become a selection parameter. Whereas the introduction of plant breeding rights has provided greater security for the breeder, the advent of micropropagation and the increasing appetite of the consumer for different products demands a more rapid flow of new cultivars of ornamental plants.

The functioning of the larger micropropagation laboratory is in many ways more closely related to a small factory than a conventional horticultural unit except for one very important difference. The product is a living one, continually changing in its requirements and responding to its environment. Monitoring and amending schedules and blueprints to guide a clone of plants through the research, development and production phases of the micropropagation laboratory and into the nursery forms a new and challenging area of horticulture.

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P. GAUT: Are you involved in the anther culture method?

M. STOKES: No.

B. RIGBY: Do you feel there are applications for haploid culture?

M. STOKES: There are applications on the breeding side. The plant breeder is interested in acquiring haploid plants for given purposes, hence the interest in anther culture.

A. CARTER: To give some idea on rhododendrons, how many would need to be ordered and roughly what price per unit would they be?

M. STOKES: Depending on the cultivar, the cost of the small size as displayed on the table would be probably 50 to 60p; for the plant direct from tissue culture, 20 to 30p.

D. CLARKE: How do you see this propagation method in hardy nursery stock during the next 5 years?

M. STOKES: I think it will depend on co-operation among growers and research stations in establishing which cultivars could be employed economically.

VOICE: What is the time limit between the growing *in vitro* and purchasing smaller rhododendrons?

M. STOKES: Between 1 year and 18 months.

D. CLARKE: Does that include the development time as well? Would that time be from when you have the first plant from the nursery to the point when you receive 10,000 back?

M. STOKES. Providing there were no hiccups and the cultivar responded well — yes, but if there were any hiccups it could be longer.

TEACHING MICROPROPAGATION

LILA W. DICK

Department of Horticulture and Beekeeping
The West of Scotland Agricultural College
Auchincruive, Ayr, KA6 5AE

Teaching micropropagation can come into various categories. It is listed in the syllabus for Higher Grade Horticultural Science in the Scottish Certificate of Education for Schools.

At the West of Scotland College it is taught to all Ordinary National Diploma students in their first year in a laboratory class and, in the third year, students from time to time have chosen some aspect of micropropagation for their third year individual projects. It also comes into the crop option of the M.I. Biology course, the B.Sc. students have a laboratory class to introduce the subject to them and as a group may tackle a micropropagation problem. When it comes to the Honours year thesis, two students have chosen some aspect of micropropagation as their remit.

At universities and polytechnics, where post-graduate courses are available, micropropagation can be part, if not all, of the investigations carried out. Under these circumstances more time is available to devote to the culture and the problems which can arise

At the West College we are fortunate in having in the Biology building, equipment available to carry out micropropagation work, i.e *laminar flow benches* (bench with sterile air coming from the back and flowing over the work area), *autoclaves* (pressure cookers to kill bacteria, etc.), *incubators* (heated cabinets

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with lights — or *growth cabinets*) and facilities for making up *media* (to grow the cultures on — these can be either solid or liquid).

Before introducing the student to the laboratory, it is necessary to give them some insight into the cleanliness needed and to "scrub up". Fortunately hospital films on the T.V. have made this easier to instill and it is carried out in a light-hearted manner! Terms too are new; *aseptic culture* (free from bacteria, etc.), *contamination* (growths of fungus or bacteria), *differentiation* (growth showing recognisable shoots and roots), *sub-divide* (putting pieces of original culture in new flasks), etc. etc.

With the OND class the method for carnation culture is used. The reasons being: 1) carnation material is easily obtained, a crop being grown in the department; 2) the small tips in the axis of the leaves are easily removed and seen; and 3) the tips already come "sterile wrapped" by the leaves. This cuts down the need to surface sterilise and although this is an important aspect it can be introduced later.

Procedures. The medium (1,000 ml of Knop's solution, 1 ml of NAA, 1 ml vit B_1 (thiamine), and 0.5 ml of Berthelot's solution. No need to adjust the pH which is about 5.5. In addition 40 gms of glucose are added (to provide carbohydrates) has already been prepared and is 20 ml amounts in flasks. The students are told that the medium has to correspond to the plant foods which would be available if the growth was in conventional soil or substrate and are made aware that the glucose will add to risk of contamination.

As well as the medium, all the instruments for use have been autoclaved, and are wrapped in greaseproof paper ready to use. We also buy pre-wrapped small sterile blades which can be used. A white tile has to be swabbed down with methylated spirit and, if necessary, instruments can be flamed after use too. All this again helps the student to realise the need for a sterile working environment.

The plant material has already been washed in distilled water and the students will isolate the small tips and put them into flasks as fast as possible. The flasks contain either solid medium (agar added) 10 or 20 ml, or the plant tissue is placed in a liquid medium on a filter bridge. Plastic flasks can be purchased sterile wrapped and are disposable or, if pyrex or monax glassware is used, they can be autoclaved.

After placing the tips in the flasks these are placed in an incubator at 20 to 23°C with continuous illumination and the students are encouraged to see the progress, or otherwise (!) of the flasks when they wish. In a few days time it is evident how much contamination has occurred and this more than anything

else gets the message across about being careful about conditions. Carnations do not take long to root and the students get the satisfaction of seeing some results from their efforts.

Individual Project - OND. This year (1980) an OND student who had previously worked at Rochfords (house plant firm) was anxious to try growing a batch of *Saintpaulias* using different sized pieces of leaf petioles 2 mm to 6 mm in a Murashige and Skoog medium, keeping it liquid and placing the pieces on a filter bridge. In this instance the student prepared the medium, made the bridges, pipetted the medium into the flasks and carried out the work at a laminar flow bench. The student learned a lot about the preparation necessary to carry out micropropagation and, although there was not any growth on the petiole segments before he left College, he did manage to get some of the flasks free of contamination.

B.Sc. involvement in micropropagation. In the third year of their course, a class of B.Sc. students (1976) carried out micropropagation techniques in *Hostas* and, although the technique was not perfected until the following year with the next group of students, they were made aware of the procedures.

Theses, 1978 and 1980. Both were under the guidance of the Botany Department of the West College and were concerned with problems connected with the production of apple rootstock 'M26' and tuberous-rooted begonias.

1978 — Walter Stewart Reid, with reference to work carried out by Jones and co-workers at East Malling Research Station on apple rootstock production looked at —

1) The potential increase rate which could be obtained *in vitro.*
2) Bacteria on or in the plant material and, if it was present, how it could be eliminated by using antibiotics, and
3) If antibiotics would prohibit or inhibit plant growth in the cultures.

As time is a limiting factor (the experimental work can only be carried out between October-March after which it has to be written up), it may be that some recommendations are arrived at for future work.

1980 — Maria dos Santos. As the culture of tuberous-rooted begonias was already in progress in the Botany Department, and with the Horticulture Department involved initially, and as a local grower had built a small laboratory on his nursery, the student was able to study certain problems in relation to this, namely:

1) the best type of ex-plant to use; bud, micro-leaf, flower peduncle or petiole segments (the latter giving the most consistent and uniform success rate).
2) Surface sterilization, using three strengths of Chloros, solutions — 2%, 5% and 10%.
3) The use of shoot and root promoting substances to get balanced growth of the petiole segments. These segments proved to be the best plant material for surface sterilization, 10% Chloros, being the suitable strength. No conclusions were drawn about 3) and further study would be needed.

To sum up. Micropropagation has such a wide and varied application in horticulture today that the necessity for methods to be taught at all levels is important. At school or college the basics are given and, if the student wishes to continue this work further, training on the job would be provided and certainly a basic knowledge of laboratory methods is necessary to begin with. A few days ago, notification of a M.A.F.F. Post-graduate studentship (University of Nottingham, Department of Agriculture and Horticulture) on "The rapid clonal propagation of tulips — (tissue culture)" came in, leading to a Ph.D. degree. The educational opportunities for micropropagation are there.

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Stone, O M 1963 Factors affecting the growth of carnation plants from shoot apices *Ann Appl Biol.* 52 199-209

B. RIGBY: You mentioned carnation and a particular recipe which you use. You buy a basic medium and then you add various millilitres of this and that.

L. DICK: With carnations, the solution was made up from scratch but you can buy the particular product. A lot of the time it is a basic Murashige and Skoog medium and then you add other things to it. A lot of the problems in making up the media have been taken away by the availability of products in packets.

A. CARTER: Can I just clear up this Chlorine/Domestos question? I think the advice was 10% Chloros — were you meaning 1% chlorine when you diluted it or are you actually using 1%?

M. STOKES: A 10% solution of the retail product

HANDLING PLANTS AT EGGERT PEDERSEN'S PLANTESKOLE, NYKOBING, DENMARK

ROGER PLATTS

Perryhill Nurseries
Hartfield, Sussex

During 1977/1978 I worked for Eggert Pedersen's nurseries on the island of Lolland in Southern Denmark doing a variety of tasks, mainly concerned with plant handling. A lack of knowledge of the Danish language obviously limited the jobs I could be asked to do.

I was interested in their system of plant handling because of the vast area covered with container plants. Approximately 80% of the staff of up to 200 were employed to move plants, and this meant that a very efficient handling system was necessary.

The plants were potted into rigid pots in a large potting shed housing four large potting benches for 16 people. During the winter the potting was done by hand; in the summer a potting machine was used.

As the plants were potted they were placed in small wooden boxes; eight 3½ litre pots were put in each box and the boxes were then loaded onto four-wheeled trailers, 33 boxes per trailer.

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The trailers were then towed to the standing ground which comprised beds two metres wide, on sand.

During the selling season plants were labelled and packed directly into Pedersen's own metal crates, small wooden boxes, or pallets with small sides. The metal crates were approximately 1 cu. metre in size and were fixed firmly to pallets. One side of the crate was hinged for easier packing and the sides could be removed so that they could be stored more easily. Pedersen's sell or lend crates to regular customers. The crates held approximately 200 3½-litre pots — the most commonly used size. Smaller pots were packed in with cardboard. The crates were ideal for carrying conifers; other larger or more brittle plants were packed in wooden boxes or large pallets with wooden sides.

The packing shed was large enough to accommodate four lorries which parked in bays which were recessed, allowing fork lift trucks to drive directly onto the lorry. All doors opened automatically. The parking area outside the shed was also designed to allow fork lift trucks to load lorries during the busy season. Orders were placed in bays around the packing shed. The metal crates could be stacked three high when full, with small wooden boxes packed on top.

Bare-rooted stock was driven to a smaller packing shed where it was sorted and packed into metal crates.

Pedersen's export to several countries, mainly other countries in Scandinavia and to Germany. Although they had their own lorries haulage contractors were often employed to export plants; refrigerated lorries were also used.

Their system appeared highly efficient and the area around the packing shed was especially well designed for large lorries to turn and for orders to be set well apart. There were over 70 trailers and one of the few problems which occurred was that unless they were kept moving through the packing shed, there was congestion around the collecting area.

I enjoyed my year in Denmark and was pleased to work in such a friendly atmosphere. Anyone who wishes to see how a large establishment copes with vast quantities of container plants is well advised to visit Eggert Pedersen's nurseries.

A. CARTER: How do they unload the crates when they get to a small nursery?

R. PLATTS: I assume they either have a forklift or they sometimes do not transport them in crates.

O. LARSEN: Many nurseries have equipment now.

R. PLATTS: There are, in my opinion, two criticisms of the crate: one they are difficult to load; it is a tricky business with a forklift truck, and then the receiving nurseries may not have one.

B. MACDONALD: Would you alter the crate in any way?

R. PLATTS: No, I think reducing the large gaps between the wires gives problems when loading small plants into it. I did say it was difficult to load, but that was to start with — and practice makes perfect.

VOICE: You didn't mention potting machines?

R. PLATTS: They did have a Javo machine, but with the large staff of 140 they cut down during the winter and concentrated on hand potting with the remaining staff.

A YEAR ON AN AMERICAN NURSERY

ALAN J. HARGREAVES

John Hargreaves and Sons
Gedney Dyke Nurseries
Spalding, Lincs.

From September, 1976, until September, 1977, I worked on the James Wells Nursery, New Jersey, U.S.A., on their English Student Programme.

Firstly, I would like to give a brief history of the nursery for those who are not familiar with it. Jim Wells left England for the U.S.A. at the end of the last war and, after spending a few years on other nurseries, he took 20 acres near the coast in New Jersey in the late 1950's. After a few years of growing quite a wide range of nursery stock the range was cut down to mainly rhododendrons and azaleas.

In 1967 the English Student Programme was started when two students from Pershore College went over to New Jersey. And so it was in 1976 that David Hill and I, having both completed our N.C.H. at Hadlow College, applied for a job at Wells Nursery. After an interview at Pershore we were selected, together with two Pershore students to go over there for a year. The flight over and back was paid for by Jim Wells and this was repaid during our 12 month stay. Whilst there we had a large apartment on the nursery. I would like to mention at this point that it is extremely difficult to obtain a work permit or a 12 month visa for the United States, but, as Jim Wells had been bringing students over for 9 years, there wasn't too much of a problem.

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The Nursery. About half of the 20 acres consisted of polythene tunnels, greenhouses, buildings, yard area, etc. and the rest was used for field production of rhododendrons. All the plants were propagated from cuttings under mist in a peat/perlite mix. The broad-leaved rhododendrons were propagated from cuttings from July right through to Christmas. A relatively thin cutting was taken, about 4 inches long leaving about 5 or 6 leaves. They were wounded quite heavily and various hormone powders were used as they had found that different cultivars rooted better with different mixtures, e.g., 1% IBA + 0.5% NAA + 0.5% Benlate, or 2% IBA + Benlate, or 0.8% IBA + captan.

The cuttings were inserted into the peat/perlite mix in beds heated by hot water pipes in a sash type greenhouse, which was heavily shaded during the summer months. Some of the easier rooting rhododendrons were propagated in double skinned heated polythene tunnels under mist, but without bottom heat. All the deciduous azaleas were propagated in early summer with mist and bottom heat.

The container stock was grown in a range of composts depending on the type and size of plant. The large rhododendrons in 3 gallon containers were grown in a peat/bark/grit mix; the deciduous azaleas in 1 gallon containers in a peat/perlite based compost; the larger deciduous azaleas in a peat/grit mix. To most of these mixes extra limestone, phosphates and granular insecticide were added; the insecticide to protect against the dreaded vine weevil. The peat was Canadian. The bark was composted on the nursery by the addition of prilled urea at the rate of 6 lbs urea per cubic metre of bark; the bark was watered and turned as the urea was added and then covered for two weeks. It was then turned every 2 to 3 weeks and, after about 10 weeks, it was ready to use.

Mixing. All the compost mixing was carried out on the concrete yard using the front end bucket on a tractor. It was then stored on the yard, covered over with plastic sheets until used.

Potting. We had a large double-skinned polythene tunnel, approximately 30′ × 120′, where we did most of the potting. High in the side of the house there were two swing doors built in, so that when opened, the compost could be fed through with the tractor bucket onto trailer benches below. After potting, all plants were drenched with a weak Benlate/Truban fungicide mix.

Feeding. As well as the superphosphate in the compost, a liquid feed of 20-20-20 plus trace elements was applied every 2 to 3 weeks in fairly low quantities. In July a high phosphate feed was used instead of the general purpose one in an attempt to improve flower bud initiation. The feeding programme for the deciduous azaleas was very much the same, bearing in mind that

they are extremely hypersensitive. They were pinched back in May and again in June. The deciduous azalea cuttings are potted off in June or July and grown on under poly tunnels and given light treatment at the rate of 20 minutes during each hour throughout the night until the autumn.

Jeeps. At some time or other, every nursery has to decide what method to use in order to transport stock around the nursery. At Wells nursery we had two army type jeeps with large platform type benches built on, one on the back and one on the front. They carried quite a lot of plants at a time and were very versatile and efficient.

Spraying. A strict spraying programme was maintained, mainly to combat the vine weevil which, if left unchecked, could wipe out a batch of plants in just a few weeks. An orchard type mist-blower was used for spraying; this was a PTO driven mounted sprayer which blasts a mist of spray from the side of the sprayer covering an area of about 25 foot at a time. Because this jet of swirling mist hits the plants from the side and not overhead we were able to achieve maximum penetration into the dense foliage of the rhododendrons.

Compared with the Americans, we in this country have very relaxed regulations as regards the use of chemicals in horticulture. On American holdings only certified operators may apply some of the more dangerous insecticides, or someone under the supervision of such a person. To obtain this certificate the operator must show a basic knowledge of the types of insecticides, their modes of action and the use of the various safety clothing and equipment when using the chemicals. These operators also have regular blood tests to check for any chemical build ups.

For all insecticide applications and poly-house sterilisations, we wore full rubber-suits, rubber boots and gloves and full face masks and respirators which were extremely uncomfortable, especially in mid-summer working in the full sun when the air temperature was in the 90's. A shower was compulsory after all spraying operations Actually the warmest day we ever recorded was 103°F when we were knapsack-spraying with paraquat around containers and taking a dip in the swimming pool between tanks.

Overwintering. In New Jersey the temperature extremes are much wider than in Britain, often falling 20° below freezing. All the container-grown stock has to be overwintered under polythene tunnels, the tunnels being covered in October and the polythene cut away in late April; this meant a lot of time spent cladding tunnels. We visited one nursery in Pennsylvania, the Conard-Pyle Nursery, which had 22 miles of polythene tunnels and had several crews cladding to get the job done.

We began cladding our tunnels in early October, doing it mainly at nights and weekends on a sort of contract/piece work basis. By the end of the month we still had quite a few to do, when suddenly early one morning, Jeremy Wells marched into our apartment to say that a freak storm was blowing down from Canada and all the plants must be protected by the evening. Now, Jim Wells had told us that his son was the "President of the Mountains out of Molehills Society" but, nevertheless, we worked through the wind and rain to clad these tunnels in record time and, true to Jeremy's word, a storm of driving sleet and snow reached us by morning.

With the polythene cladding over them, the rootballs in the pots still froze solid in mid-winter and, even when the temperature was 15 or 20 degrees below freezing at mid-day, with the wind chill factor making it even colder, the sun would shine brightly and the polyhouses could get quite warm, so we had to irrigate to get some moisture around those frozen rootballs.

The Move. During my year out there I was involved in the moving of the nursery from New Jersey to the Blue Ridge Mountain Range in North Carolina. Every piece of equipment, every tool, implement, every single poly-house, all the rooted cuttings and growing stock — the whole nursery, in fact, was transported in 40-foot trucks, 750 miles by road over a period of about two years.

There were many reasons for moving the nursery, probably the most important reason was that New Jersey is *not* the "Garden State" any more and there was little chance of expansion in that area. After looking at many different areas in the States, Jeremy Wells finally decided on Transylvania County, North Carolina. The climate is ideal for rhododendrons as the Catawba Mountains are nearby, home of the Catawbiense range of rhododendrons. A 60 acre site was found, approximately half rolling pasture and half wooded hillside. The soil is ideal for growing rhododendrons, and there is a virtually unlimited water supply from the mountain streams supplying a central pond. The land is situated in such a manner that it is protected from the north, east and west, and open to the south allowing extremely high solar radiation. Drainage is good. Bark is obtained locally. North Carolina is centrally situated for supplying the entire eastern half of the United States.

There are a few disadvantages as well. Jeremy recorded a 70°F temperature change in 12 hours and that is supposedly a very common occurrence. He has also had frost as late as May 20th and as early as September 10th.

And so piece by piece the nursery was dismantled and moved. The hoops in the poly-tunnels were originally 4 foot

apart, but after a trial on a couple of houses it was found that with the hoops at 8 foot intervals they would still stand up to the 50 or 60 inches of snow which falls every winter. Every house had half its hoops removed and these were moved down to Carolina for erecting.

Propagation was carried on in New Jersey for a couple of years while the growing side was being built up down south by Jeremy, and it was during one of the main plant moving periods that a major catastrophe occurred. A 40-foot truckload of plants left the old nursery, supposedly bound for North Carolina but, the trucker had other ideas and hi-jacked the lot. The truck and plants disappeared including the entire stocks of some cultivars. There seemed to be no chance of recovering the plants. The situation was well publicized in the "American Nurseryman" and, to cut a long story short, the whole load was recovered essentially intact. The plants had been sold by the hi-jackers to various retail outlets as far south as Florida and Alabama for only a fraction of their value but, fortunately, after hearing of Wells' crisis, the retail nurserymen contacted them and almost all the stocks were recovered — some a little worse for wear.

Since I left the States the new nursery has expanded rapidly; 130,000 rhododendrons and 60,000 deciduous azaleas are being propagated this year and Jeremy is hoping to double the quantity within 3 years.

QUESTION BOX

CHAIRMAN — B. MACDONALD

1. When growing holly cuttings in double glass frames, would leaf drop be caused by a) too high a temperature, b) too high a light intensity, or c) any other factor? The cuttings were taken in late September and dipped in Seradix 3

VOICE: I got leaf fall when the cuttings were too close in the bed.

DOUG HARRIS: I always assumed it was the high temperatures.

B. MacDONALD: Could it be too high an air temperature? My experience particularly with *Ilex aquifolium* types is that they are prone to this, taken in late August or early September.

2. Have any members tried the new range of Vitax Q.S. fertilizers? If so with what results?

VOICE: We have just completed a small trial but it is still too early for the results?

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2. Have any members tried the new range of Vitax Q.S. fertilizers? If so with what results?

VOICE: We have just completed a small trial but it is still too early for the results?

3. Have any members evidence of a build up of Specific Replant Disease in older layer or stool beds?

D. HARRIS: There is no evidence of this in rhododendron layer beds that have been used for 40 years now. I thought there was a replant problem on roses at one time but we found no evidence for this.

4. Arthur Carter said "Netting is more durable than polythene" — this is not born out by our experience, i.e. Netting does not last for us more than 2 or 3 seasons.

Before we start could we establish what sort of netting is used, was it hand stitched or purchased by the roll, and how did it deteriorate and break down?

J. ANSTEY: We usually use Rokolene.

A. CARTER: Some that are still going strong, mainly Nicofence 31, and 17/28.

D. CLARK: We have had some up for 3½ years, problems have been mainly holes and ladders.

J. GAGGINI: It looks as though we should use the polypropylene rather than the polythene type.

D CLARK: A word of warning especially on thermal screens. Starch is used in the final stages of manufacture and a fairly harmless fungi has caused some discoloration.

5 Would it be an advantage to test Long Ashton clones in other parts of the country?

I CAMPBELL: Obviously there would be advantages in getting in as many places as possible but it's a question whether they can cope. Obviously some of the clones selected will not be suitable for Aberdeen. I suspect that they would do differently in different parts of the country. The easiest way of comparing what we are growing is to bring some onto the nursery and, if they are no better, then keep as you are.

A. CARTER: I think one of the problems is that of communication. We know that some growers have not read of the scheme in the trade press. If you could see the selected plants in different parts of the country then more growers would be keen on it.

6 Could I.P P S. members be circulated as to subjects to be sent for trial?

I. CAMPBELL: I would agree with this, for notices in the press are ineffective.

T. WOOD: It could be included in the I.P.P.S. newsletter.

D. CLARK: I discussed this with Brian after yesterday's discussion and he agreed that communications could not rely on the press, but he would investigate sending a circular via the HTA/NFU circulation list.

T. WOOD: Clonal selection is very dear to us and we do want to keep it going.

TECHNICAL SESSIONS
Tuesday Morning, December 8, 1980

The thirtieth annual meeting of the Eastern Region of the International Plant Propagators' Society convened at 8:15 a.m. in the ballroom of the Copley Plaza Hotel, Boston, Massachusetts.

PRESIDENT LOVELACE: Welcome to the thirtieth annual meeting of the Eastern Region of the International Plant Propagators' Society. This is shaping up to be one of the largest meetings this group has ever had. Our registration right now stands at 528 which I think speaks well for everyone who has been involved in planning this meeting and the site that was selected. We want to certainly thank the people here in Boston, particularly Wayne Mezitt and his crew, who have worked so hard to make our stay here in Boston a pleasure. At this time I would like to introduce to you the person who has to do all the hard work at these meetings, your program chairman and vice-president, Dr. John Wott.

VICE-PRESIDENT WOTT: It certainly is gratifying to see so many of you so early this morning. I would like to welcome you to your program. This is your program. It was put together based on the responses and ideas you gave me and other people on the Executive Committee. One of the things I would like to have you keep in mind as we go through the meeting is — if you get an idea please let the Executive Committee, and particularly John Sparmann, know. We really do need your help and it is an asset to us if we can know what you want. The other thing is that this program is for you and we want your participation. This has always been one of the strong attributes and one of the things the Society has been known for. So again, it was my pleasure to put this program together for you and to be here with you. I will now turn the program over to our first moderator, Don Shadow.

ROOT INITIATION: A SURVEY OF CURRENT LITERATURE[1]

JOHN J. McGUIRE

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Initiation of adventitious roots results from the interaction of numerous interrelated physiological and anatomical factors. In a summary of the subject in 1974, Snyder (32) reported that such an event depends upon the presence of cells capable of dividing

[1] Contribution No. 1979 of the Rhode Island Agricultural Experiment Station

and differentiating as root initials as well as the presence of favorable internal and external environments. In other words, a cell must be living and undifferentiated.

It has been known for many years that auxin (IAA) or one of its derivatives is a major controlling factor, but we still do not know specifically how auxin exerts this control over cell function. We know it stimulates root initiation in a manner similar to *cytokinin, polyphenols, gibberellins, carbohydrate, boron, nitrogen* and a host of other organic compounds. We know also that it is not the absolute amount of plant hormone that exerts this action but rather the relative amounts of each in proportion to the other. Most recently it has been suggested auxin may be just another cofactor functioning in electron transfer (2). We know the morphology and anatomy of the plant part is critical as well as that of adjacent parts, since translocation and storage of the organic stimulants play a part in initiation or obstruction of roots. Obstruction can be caused by fiber cells and disruption of newly formed initials may be caused by resin-producing cells.

Newly expanding leaves and actively growing buds, as well as dividing cells in the vascular cambium synthesize auxin which is translocated through phloem tissue to the crown of the plant. Not all buds are critical for root initiation. Wareing (36) found that dormant buds are not required for rooting, since removal of them did not inhibit rooting. Also, Biron (6) found that removal of the actively growing shoot tip and buds of dahlia increased rooting. He claimed that removal of the leafy shoot reduced competition for metabolites needed at the site of root initiation. Propagators have followed a similar line of reasoning when they removed flower buds from cuttings. In a related practice propagators conserve carbohydrates in cuttings by keeping above ground portions of cuttings cool while allowing photosynthesis to take place. Hess (16) demonstrated this through increased rooting with intermittent mist as a carbohydrate conserver.

The influence of fiber cells as an inhibitor to root development has been debated. Sachs, *et al* (26) believe proper cutting treatment and manipulation of environment could overcome any physical barrier. Girourard (14) also found sclerenchyma was not a barrier to adventitious root initiation in his studies with adult *Hedera helix* Yet, Howard (17) found that wounding to remove some physical barriers to root initiation consistently improved rooting. Edwards (12) further reported that wounding allowed for horizontal emergence of roots. He suggested that wounding may also allow for the free diffusion of root promoting substances and gases and that it allowed the root initials to make vascular linkages.

The dimorphism observed in the juvenile growth form and

the correlated physical and biochemistry of juvenile growth forms have long been known to be linked to ease of rooting (3,4,5,13). However, it is a broad subject and too large to be summarized in this paper in depth. Only some recent findings will be discussed.

Kester (19) mentioned that the adult phase of *Hedera helix* could be reversed to the more easily rooted juvenile form by grafting the adult form to juvenile shoots and by the use of gibberellins and auxin. Roberts (24,25) has done extensive work on juvenility and time of taking cuttings of Douglas fir. He found changes in the meristem from one phase to another results in a change of metabolites being transported to the growing points. He noted that while the practice of shearing stimulates growth that is easy to root it does not result in morphologically altering growth. It does, however, alter the C/N ratio, auxin distribution, inhibitor-promotor balance and relative levels of cytokinins and gibberellins. He suggests the practice be referred to as "invigoration."

The interrelationships of morphological, anatomical and physiological factors are so tightly interwoven that they cannot actually be separated.

Albert (1) demonstrated the need for boron in root elongation. He pointed out that many root initials may never be seen because they cannot develop with insufficient boron. This conclusion was supported by Weiser (37). Further, Bojarczak (7,8) used borate in a talc formulation to increase root number and root length in lilac.

Numerous studies on environmental factors, primarily light and temperature, as they affect rooting, have been conducted. The influences of O_2, CO_2 and humidity on this process have also been investigated.

The advantage of conserved carbohydrate was mentioned previously as was the manipulation of removing competing plant parts during rooting. Propagators have also used differential heating or bottom heat to encourage root initiation while retarding top growth. Nelson (23) studied this topic extensively. He found few papers that actually demonstrated direct beneficial value in using bottom heat. Albert (1) reported that the optimum temperature for root growth is 20 to 25°C, and that higher temperatures can be detrimental. It is quite possible that the optimum temperature for root initiation is not the same as for root development. Dykeman (11) found a temperature of 27 to 30°C best for root elongation for many species.

Lamb (21) found that alternating temperature in the rooting medium was beneficial. He used higher temperature at night while keeping the air temperature cool. While many propagators

are using bottom heat in the range of 25°C, several researchers have found lower temperatures to be beneficial. Van Elk (35) found that the temperature of the rooting medium should be maintained at not more than 20°C for rhododendron cuttings. Sanders (27) also reported that 20°C was optimum for *Rhododendron, Mahonia* and *Ilex*.

The light requirement for rooting is quite complex. Light is required for photosynthesis and carbohydrate accumulation. Light duration and quality also have a direct controlling influence on photoperiodic stimulus and many other factors of plant growth and rooting, such as phenolic and hormonal content.

Perhaps of more significance, is the absence of light and resultant etiolated growth. Etiolated portions of stems appear to be easier to root (9,10,20). Moreover, cells developed in the absence of light are physiologically different. Krul (20) found that 2,4-DNP stimulated rooting and that higher levels of this are conserved in etiolated cells or the phenol was not metabolized to an inactive form when stems were etiolated.

Bojarczuk (7,8) found a positive relationship between the presence of phenol and the ease of rooting in lilac. Krul (10) speculates that wounding of cuttings may be beneficial to rooting because the action of wounding releases phenols from injured cells

Instead of physically wounding stems it has been suggested recently that chemically treating the stem base may also stimulate rooting Lee (22) found that soaking basal stem portions in either strong acid or base improved rooting. This was supported by Gray (15) who applied the acid soak to a fall crop of *Rhododendron* cuttings. However, Ticknor (34), using this method on bearberry, could find no benefit. We have followed Gray's procedure on summer cuttings of the same rhododendron cultivar and no beneficial results were found. Lee (22) believes the acid soak may break acid labile bonds, loosen cell walls, and facilitate absorption of applied auxin.

The effects of growth retardants and ethylene are at present under extensive study. Kawase (18) found ethylene stimulated rooting on willow. Swanson (33) suggests ethylene treatment may alter levels of various metabolites and may increase the number of endogenous root promoting substances or decrease inhibitor levels. He suggests repeated treatments may be necessary for difficult to root plants.

The possibility of repeated treatments or gradual changes in treatments is one that warrants a more serious look in the future. It has been suggested that environmental changes should be made as the cutting goes from the root initiation stage to root

development. Several researchers have suggested that repeated applications of chemicals might be beneficial. One even suggested the formulation of slow release plant growth regulators

Further evidence for such an approach can be found in a series of papers by Sircar (28,29,30,31). He found five stages of meristematic development during adventitious root initiation. The effect of application of gibberellins or IAA was more or less effective depending upon which stage the gibberellins were made A concentration of auxin or gibberellins applied at one stage may be inhibitory, while at another stage it may be a stimulant.

Another aspect of plant propagation often overlooked is environmental treatment of the stock plant prior to taking the cutting.

Roberts (25) summed it up well when he said that timing the taking of cuttings to coincide with their achieving maximum potential is still one of the goals of the plant propagator.

If we add to this that best results will be obtained from the proper timing of application of treatments and formulations of growth regulators and regulations of environmental factors, we may yet achieve our goal of asexually propagating all clones at maximum efficiency.

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VOICE: I would like to know what you find in relation to pH and rooting. Does pH act differently during different stages of the rooting process?

JOHN McGUIRE: From the little work that has been done on this subject it is difficult to separate the reported effects into the various stages of root initiation. My own personal feeling is that with some plants that are particularly dependent on an acid or basic medium that there would be a difference. I think I have seen it in some plants, particularly clematis, where we have found that you do not get root development if you use an acid medium.

RICHARD FENICCHIA: I would like to comment on juvenility and rooting. Juvenile cuttings possibly root better because they store more hormone which is important in root initiation. You also have to have the nutrients present to help in the development of roots.

GUSTAV MEHLQUIST: I noticed that you mentioned rhododendrons several times in your presentation. I would like to suggest that you refer to what kind of rhododendrons you are discussing. There are 1800 or more species comprising several sections which grow quite differently and would have to be treated quite differently. I have noticed that in previous meetings that red flowered rhododendrons have been referred to as being hard to root. This may be true for *Rhododendron catawbiense* but not necessarily for other red species.

JOHN McGUIRE: In my own work I did refer to R. 'Nova Zembla'.

MARTIN MEYER: I would just like to comment on bottom heat. If you read Nelson's work on bottom heat he reported that 6 species gave a favorable response and I think he had 66 species that showed no response or a detrimental one. So, if a person is thinking of using bottom heat, one should start on a small scale.

SEASONAL ROOTING CHANGES IN APPLE HARDWOOD CUTTINGS AND THEIR IMPLICATIONS TO NURSERYMEN

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Abstract. Vacuum-extracted root promoting cofactors from M.26 apple hardwood cuttings were found to correlate positively with M.26 seasonal rooting fluctuations. These substances were present throughout the stock plant as well as in previously disbudded cuttings. An abundant phenolic — phloridzin, and a polyphenol oxidase enzyme, also found in the extracted sap appeared to fluctuate in a way which implicated them as precursors of the root promoting co-factors. When the products of this phenolic reaction were added to IBA, rooting was significantly increased in mung bean and apple hardwood cuttings.

REVIEW OF LITERATURE

Traditionally, clonal apple rootstocks have been propagated by stooling or layering (7). Hardwood cuttings collected between October and April are being increasingly used to supplement older techniques (9). Although the hardwood cutting technique has advantages such as higher shoot productivity per plant and decreased labor requirement during summer compared with stooling, its limitation from a management perspective is a marked seasonal variability in rooting.

Typically, M.26 apple hardwood cuttings root moderately well (40% to 90%) during autumn, but between November and early February, depending on the year, there is a sharp decline in rooting (0% to 20%), followed by an equally rapid rooting increase during mid to late winter which remains high (70% to 100%) until late April, when bud break occurs and rooting again decreases (8).

A commonly held view based largely on a loss of rooting in disbudded cuttings is that increasing bud activity in late winter produces root promoting substances which are translocated to the basal end of the cutting and thus stimulate root initiation (15,6,12). Howard (10) later found that the addition of an anti-desiccant to the cut surfaces of disbudded apple, pear and plum cuttings largely nullified the negative effect of disbudding on rooting and further showed that seasonal rooting patterns were unaltered by the presence or absence of buds on hardwood cuttings of apple and plum (8).

Bouillenne and Bouillenne-Walrand (5) hypothesized that phenolic cofactors and auxins stimulate rooting in the presence of a polyphenol oxidase (PPO) enzyme. Past attempts to correlate

seasonal rooting trends with extracted root promoters have been only partially successful (11,6,14,13). This study, therefore, was aimed at finding the cause of seasonal rooting in M.26 apple cuttings using a more physiologically sensitive technique based on vacuum extracted sap rather than extraction with methanol or ethanol as used by other workers. Furthermore, seasonal levels of PPO enzyme and phloridzin, the abundant glucoside in apples (16) were also investigated.

MATERIALS AND METHODS

Hardwood cuttings, 60 cm in size, were taken from severely pruned hedges and treated with 2500 ppm IBA and propagated for four weeks at 20°C bottom heat in a peat/grit compost at intervals through the winter. At the same time, sap was obtained from other cuttings by reducing pressure at their bases while simultaneously cutting back their tips (4).

Sap co-factor content was investigated by paper chromatography and enzyme activity by colorimetric methods using catechol oxidation. Phloridzin was determined by measuring its absorbance at 283 nm after purification by chromatography.

Rooting co-factors were synthesized by reacting a commercial source of polyphenol oxidase enzyme (PPO) with phloridzin and applying it to mung bean or apple cuttings in the presence of 2 ppm IBA, respectively.

RESULTS

Root promoting activity was found in normal as well as disbudded shoots, roots and thick branch framework. Eight discrete areas of activity containing substances which were phenolic in nature, consistently appeared on the chromatogram as determined by the mung bean rooting bioassay (1) (Table 1). There was little or no activity however, when IBA was not added indicating that these substances are auxin co-factors.

Table 1. Mung bean rooting response to apple root and shoot sap in the presence of 2 ppm IBA.

Co-factor chromatogram location (Rf)	Roots per cutting
0→.06	18.3
.06→.20	23.8
.20→.27	18.8
.33→.41	15.4
.45→.51	12.0
.57→.69	18.3
.80→.90	23.6
	Control = 7.9 roots
	LSD 5% = 4.3 roots

Cutting collection and extraction of sap was carried out in conjunction with normal seasonal rooting experiments both in

1977-1978 and 1978-1979. There was a highly significant correlation between the levels of co-factors found in the sap and rooting of cuttings throughout the season (Table 2).

Table 2. Co-factor activity in relation to rooting percentage in M.26 cuttings for 1977-78 and 1978-79.

Date of collection	Percent rooted M.26 cuttings	Co-factor activity (no. of mung bean roots more than controls)
(1977-1978)		
11/10/77	88.8	19.4 (4 cofactors only)
12/15/77	83.8	20.2
1/19/78	38.0	14.5
2/27/78	38.2	16.3
3/20/78	96.3	29.2
4/18/78	92.5	19.8
(1978-1979)		
11/ 7/78	48	50.6 (all 8 cofactors)
12/12/78	58	45.5
1/22/79	22	33.4
2/5/79	64	41.8
2/19/79	84	73.3
3/26/79	86	72.9

PPO activity and phloridzin content increased significantly ($P<0.001$ and $P<0.01$, respectively) in late January and early February 1979, preceding the concurrent rises in M.26 rooting percentages and cofactor activity in the sap (Table 3).

Table 3. Phloridzin content and PPO activity related to cofactor activity and rooting percent of M.26 cuttings.

Date	Phloridzin	PPO	M.26 rooting	Co-factor
11/7/78	12.7	5.8	48	50.6
12/12/78	13.3	5.2	58	45.5
1/22/79	20.8	9.1	22	33.4
2/5/79	23.2	8.6	64	41.8
2/19/79	21.8	8.2	84	73.3
3/26/79	17.7	8.5	86	72.9

The interaction of all three factors: auxin (IBA, 2 ppm); phenolic (phloridzin, 2×10^{-3}M); and active and denatured (boiled) PPO enzyme (400 units tyrosinase), was tested in the mung bean bioassay. Table 4 shows that a dramatic rise in rooting occurred by adding active enzyme to phloridzin and IBA.

Table 4. Mung bean response to polyphenol oxidase, phloridzin and IBA.

Treatment	Mung bean roots/cutting
IBA	7.0
IBA + phloridzin	7.8
IBA + phloridzin + denatured enzyme	9.2
IBA + phloridzin + active enzyme	26.7
	LSD 0.1% = 2.9

When testing these compounds on hardwood cuttings at the

poorer rooting time of year, higher concentrations of the same phenolic glucoside (400 ml of 10^{-2}M) and enzyme (160,000 units tyrosinase) were reacted together and then added to the standard 2500 ppm IBA quick dip. Rooting percentages rose significantly from 20% with IBA alone to 38% with the phloridzin-PPO reaction products plus IBA and root numbers were doubled.

DISCUSSION

Rooting co-factors in vacuum extracted sap showed a strong correlation with seasonal rooting patterns in M.26 hardwood cuttings over 2 years. As co-factor activity was present throughout plant tissues regardless of the presence or absence of buds, it is likely that the source of the seasonal stimulus is in the tissues of the shoot itself. Moreover, shoots isolated from the hedge plant in autumn, placed in cold storage, and propagated subsequently along with field collected cuttings also exhibited typical seasonal rooting trends (2).

The rise in PPO activity and phloridzin content which just preceded the rises in co-factor activity and rooting may indicate a causal relationship whereby PPO and phloridzin are the precursors of the co-factors that influence hardwood cutting rooting. This idea is strengthened by the fact that PPO and phloridzin caused large rooting increases in mung bean cuttings when applied in the presence of IBA. Other similarities between the sap extracted co-factors and synthesized PPO-phloridzin products have been reported by Bassuk, *et al* (3).

The significant rooting improvement of M.26 cuttings treated with the products of a phloridzin-PPO reaction in the presence of IBA at the normally poor rooting time of year (20%, February 1979) was encouraging as little work had been done to test various concentrations or methods of applying these synthesized cofactors.

The implication of this work for nurserymen is that in future they may collect hardwood cuttings at times convenient to themselves and treat them with rooting co-factors to obtain consistently high levels of rooting. The possibility also exists to improve the rooting of difficult-to-root subjects and to alter cold storage practice by not removing cuttings from the hedge until adequate levels of precursors or co-factors have developed.

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BRUCE BRIGGS: How do you get the phloridzin to work? We have tried it a number of years and have not been able to get it to work.

NINA BASSUK: It is not the phloridzin but the products of the enzyme and phloridzin that are the active substances.

BRUCE BRIGGS: Is phloridzin destroyed by heat in sterilization?

NINA BASSUK: No.

THE ISRAEL SOCIETY FOR PLANT PROPAGATION[1] — A NEW DEVELOPMENT IN THE DYNAMIC ISRAELI HORTICULTURE

J. BEN-JAACOV[2]

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Israel is a very small country — its area is somewhat smaller than the state of Massachusetts (7800 sq. miles), and its population somewhat less than the Boston metropolitan area (3.8 million). More than half of the land is desert. The rest of the country has a Mediterranean climate with hot, dry summers and cool, rainy winters. Rainfall varies from 30 inches in the north to 1 inch or less in the south.

Rapid development of the country's agriculture led to full usage of the available irrigation water by 1960. In the last 20 years (1960-1980), agricultural production has tripled without increasing the amount of water and land used (2). This intensification of agriculture was brought about by active endeavor through research and development as well as by the dynamic farming community.

Floriculture plays a leading role in the country's intensive horticulture. In 1979/80, 5800 farming families produced about 80 million dollars worth of flowers for export to Europe and the United States.

Although the main kinds of flowers produced are miniature carnations and roses, there has been a large increase in the last few years in the production of other floriculture crops (Table 1).

Table 1. Values (million U.S. dollars) of flowers and other floricultural commodities exported from Israel in 1975-1980.*

	Year				
Product	75/76	76/77	77/78	78/79	79/80
Roses	10	12	20	26	30
Carnations	6	12	22	26	30
Others	1	2	6	14	22
TOTAL	17	26	48	66	82

*Israeli Flower Grower Association (1980). The 31st meeting of the International Federation of Flower Growers Association — Tel Aviv 1980.

There is a great effort in the development of new and unique flower crops and other horticultural commodities. Recently much interest has been focused on propagation of plant material for export. High quality propagating material is presently being exported to Europe and the United States which include:

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[1] The Israel Society for Plant Propagation. P.O. Box 2093, Rehovot, Israel.

[2] Presently on leave at the Agricultural Research Center, Route 3, Box 580, Apopka, FL 32703.

hybrid petunia seeds, the new outstanding paperwhite *Narcissus* bred in Israel, and other bulbs and corms. Rooted and unrooted cuttings of carnations and foliage plants, citrus and olive plants are also on the export list. Several modern tissue culture laboratories produce a wide range of plants for export as well as for the local market.

This dynamic involvement of farmers in nursery production brought about a need for the creation of *The Israel Society for Plant Propagation*. There are 250 members in our Society, including commercial plant propagators and nursery managers, some amateur plant propagators, research, teaching, and extension personnel.

The program of the meetings include a wide variety of subjects — some are very general and others deal with specific subjects (Tables 2, 3, and 4).

Table 2. The Israel Society for Plant Propagation: Proceedings of the First Meeting. May, 1979 (3).

R - Historical Outlines of the Nursery Industry in Israel.
R - The Need for a Professional Society of Plant Propagators.
R - Improvements and Developments in Rooting of Cuttings
R - Industrialization of Plant Propagation and Nursery Management
R - Growth Regulators in Plant Propagation and Nursery Management
R - Questions and Answers — Panel of Experts
- Business Meetings: Outlines for Organization

R = Presented by research personnel.

Table 3. The Israel Society for Plant Propagation, Proceedings of the Second Meeting — October 1979, (4).

R - "Isaiah's Vineyard Song: Allegory and Practice"
R - Propagation Material: The Desirable and the Available.
R - Control of Irrigation and Fertilization in Containers
R - The Effect of Environmental Factors on the Rooting of Cuttings
R - Propagation Problems with Palms
C - Propagation of Disease-free *Gypsophylla*
C - Hardening of Tissue Cultured Propagated Bromeliads and Ferns
R - Production of Croton Cuttings: An Experimental Model
C - Problems in Cactus Propagation
C - Propagation of Shade Loving Plants
R - Propagation of Bulb Crops
R - Propagation of Grapevines by Traditional Methods
C - Mist Propagation of Grapevine Cuttings with Leaves
R - Rooting of Woody Apple-Rootstock Cuttings
R - Apple-Rootstock Propagation by Tissue Culture
R - Improved Rooting of Avocado Cuttings by Etiolation
C - Avocado and Mango Problems and Achievements
C - Growing Citrus Plants under Insect Proof Netting
C & R - Questions and Answers — Panel of Experts.

C = Presented by commercial personnel.
R = Presented by research personnel.

Table 4. The Israel Society for Plant Propagation, Proceedings of the Third Meeting. October, 1980 (5).

R - Genetic Engineering and Agriculture in the Future.
R - Mycorrhiza and Nursery Production in the Future.
R - Light and Nursery Production.
R - Technology of Mist Propagation.
C - Woody Plant Propagation by Grafted Cuttings.
C - Incorporating Other Crops into Carnation Propagation Nurseries.
R - How to Import New Plants — The Quarantine Service.
C - Seed Propagated Pot Plants.
R - *In vitro* Propagation of Lilies.
R - Peach Propagation for Meadow Orchards.
C - Rooting of Citrus Cuttings in Aeroponics.
R - Etiolation Increases Rooting in Avocado
C - Rooting Grapevine Rootstocks.
C - Rooting Dwarf Apple Rootstocks.
C & R - Questions and Answers — Panel of Experts.
- Business meetings.

C = Presented by commercial company personnel.
R = Presented by research personnel.

Many of our members are new in the nursery business. They are very dynamic and eager to learn. Experimentation and new innovations are common in our nurseries. New, sometimes sophisticated methods of propagation and production are often tried. Tissue culture, disease-free stock, insect-proof houses, hydroponics, aeroponics, new crops, air-root pruning and intensive cultivation are often used terms.

Exchange of ideas and information between our newly formed Society and *The International Plant Propagators' Society* is of mutual interest and benefit.

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Editor's Note: Joseph Cesarini moderated a group of short presentations on tricks and ideas in propagation and growing. The following papers by Carl Orndorff, Clayton Fuller and Ralph Shugert were part of that session.

VACUUM VENTILATION OF PLANT PROPAGATION STRUCTURES[1]

CARL ORNDORFF

Kalmia Farms Nursery
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The principle of using vacuum ventilation for propagating structures has been used for several decades and is not a new innovation. When one sees the inefficiency of some of the ventilating systems being used and the incorrect use of some vacuum systems now in use, it would seem a review of the merits of this system would be in order.

The vacuum system is of most value to early summer softwood cuttings of deciduous shrubs and trees, plus certain broadleaf evergreens. It may be efficiently employed for all types of plants at all times of the year.

This is a low cost installation consisting of a thermostatic controlled input louver for the admission of outside ambient air into a large diameter punched plastic tube for the entire length of the structure. The flow of air into the louver and tube is created by a vacuum made by a termostatic controlled large slow speed exhaust fan on the same end of the structure as the input louver.

Many structures ventilated by vacuum systems use fans of too high speed, too small louvers, and too small punched tubes. The air moves too fast causing excessive evaporation and therefore, the dehydration of cuttings.

Large belt driven fans, 30 or 36 inches in diameter, with large drive wheels are normally used. Dual or multiple speed electric motors, with small drive pulleys, are more easily speed adjusted. Initial calibration adjustments are made by changing the size of the small drive pulley on the motor. Direct driven fans, mounted on the motor drive shaft, are too fast and unadjustable. Input louvers and punched tubes are usually 24 or 30 inches in diameter. Tubes with two inch holes, spaced two foot apart, in two rows spaced at the three and nine o'clock positions are best. Too large or too many port-holes fail to draw air uniformly the full length of the tube.

Calibration and adjustment are the most important factor involved. Houses vary in many ways so that a uniform scientific formula is almost impossible. Houses are different in length, width, air leakage, type of construction, type of equipment, and placement of equipment. Terms such as *cubic feet per minute*, or *revolutions per minute* cannot be used.

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[1] Vacuum ventilation is also referred to as negative pressure ventilation.

Simple adjustments may be made by checking the airflow through a door on the end of the house opposite the fan and input louver. With all doors closed the input tube should be firmly and uniformly filled the full length. A door crack of six or eight inches should completely deflat a filled tube in fifteen to twenty seconds. If it does not the fan speed should be decreased. Increase or decrease the fan speed until the tube will deflate at the air leakage caused by the door crack. Changing the motor drive pulley size by one-half or one inch diameter is usually all that is necessary. Increasing the motor drive pulley size increases speed of the fan. Decreasing the pulley lowers the fan speed. The use of multiple speed or slow speed motors, if available, should make adjustment easier.

Excessively wide houses may have two input louvers and tubes, but only one fan. The input tube should be placed at the highest possible point and the fan also high if possible. The automatic mist systems are used in the conventional way to maintain humidity. Twenty-four hour time clocks should be used to avoid continuous air conditioning during excessively hot nights. Flame-proof type polypropylene net shading, preferably about fifty percent shading, will still be necessary during the summer period from April to October. In 90°F weather, inside and outside temperature differences of under 10°F are normal.

Some systems use variations of the wind tunnel principle, not good engineering for plant propagation. One type uses cooling pads, moistened continuously with water at the input and with an exhaust fan at the opposite end of the structure. This is more expensive in installation, operation, and maintenance for both materials and labor. Results are good, but questionable as to being superior over vacuum ventilation for softwood cutting propagation. A smoke generator used about the propagation house may offer considerations for ventilation design.

HUMAN AND NATURAL ENERGY SAVERS

CLAYTON W. FULLER
Bigelow Nurseries, Inc.
Northborough, Massachusetts 01532

I believe that we must continually strive to find ways in which to conserve our natural and human energy resources. Therefore I present to you these few ideas which may or may not be useful in your operations.

How many times over the years have we been guilty of this little trick? Kinking the hose single or in a double kink. This is

Simple adjustments may be made by checking the airflow through a door on the end of the house opposite the fan and input louver. With all doors closed the input tube should be firmly and uniformly filled the full length. A door crack of six or eight inches should completely deflat a filled tube in fifteen to twenty seconds. If it does not the fan speed should be decreased. Increase or decrease the fan speed until the tube will deflate at the air leakage caused by the door crack. Changing the motor drive pulley size by one-half or one inch diameter is usually all that is necessary. Increasing the motor drive pulley size increases speed of the fan. Decreasing the pulley lowers the fan speed. The use of multiple speed or slow speed motors, if available, should make adjustment easier.

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not only a waste of natural energy because we will have to replace the hose before its time, but also a human energy waste in that we will have to use it to repair or replace the hose. For the past several years we have eliminated this waste by simply using a ¼ turn valve attached to the end of the hose. This conserves on human energy by not having to walk back and forth to the faucet to adjust the water flow, but also by extending the life of the hose. When a person can make the necessary water adjustment where he is watering, it not only conserves on water, but we find that the watering job is much more efficient in that the person will not tend to underwater or overwater the plants.

Another human energy saver we find to be very effective is using the same valve with a hose nozzle attached to it for washing the glass inside, washing the drip grooves, actually using the water pressure to flake off peeling paint prior to painting, which eliminates approximately 85% of the hand scraping. By using this method, we are also washing away any accumulation of pesticide residue that has built up inside the greenhouse. We also use this valve to wash down the aisles, thereby preventing a buildup of soil or other foreign matter which could cause lost man-hours due to a slipping accident.

One of our greatest savers, of course, was the introduction of hydraulic digging machines which not only save human energy but, we believe, greatly insures the ability of the plants to survive after being dug.

In dealing with natural energy in today's rising costs we are naturally trying to get the most for our energy dollar. Over the past few years we think we have obtained this goal in our minimum heat storage houses. We are trying to utilize every square foot of space available with storage on the floor and 3 racks above that. We also install a temporary side bench to utilize that space. The 22′ × 80′ house is heated with a 150,000 LP propane heater. With pot sizes ranging from 2½″ to 1 and 2 gallon containers, we winter store approximately 77,000 plants in this house. Our total cost for heat for this house and one other the same size was $512 for the 1979-80 winter season.

Because of the tremendous amount of material being stored in these houses, we feel it is vital to have good air movement when the temperature reaches 60°F, as the top racks tend to be much too warm for winter storage. Therefore each house has temperature alarms and automatic vents.

As an energy saving device, we installed a 9″ stove pipe elbow through the end of the house and simply attach it to the heater with duct tape to keep out unwanted cold air when the heater is not running.

A RACKING AND CONVEYOR SYSTEM FOR INCREASED EFFICIENCY

RALPH SHUGERT

Zelenka Nurseries
Grand Haven, Michigan 49417

This year Zelenka Nurseries shipped over 2,000 truck loads of plants into 34 states and regions of Canada. We presently ship from 3 loading and staging areas and during the peak shipping season we will load up to 40 trucks per day.

We have developed an aluminum 3-deck racking system to maximize loading area and minimize damages. This system consists of 12 racks and 96 boards for a 40 foot trailer. The racking system weighs 2,322 lbs. and the cost is $3,894 (Tables 1 and 2). We will have 80 sets available for spring 1981 shipping.

Variable speed electronic conveyors are used to load plants into a truck. We presently have 16 conveyors ranging from 35 to 40 feet in length. Currently conveyors are costing about $4,000. Electronic eye counters are mounted on the conveyors to improve loading accuracy. Counters can be set for subtotals as well as totals. It takes 4 to 8 man-hours to load a full trailer and we are able to load over 1,700 spreading junipers 12 to 15 inches on a truck. The end of the load is secured with clamps and load locks to insure it stays intact. Some haulers have made special brackets underneath their trailers to store the racks. This helps allow for more profitable return hauls for the drivers.

Table 1. Advantages of Aluminum Racking Systems.

1. Longer life span — 10 years opposed to 3 years for wooden systems.
2. All racks are uniform and deck height is consistent.
3. Rack design allows us to load right up against the walls on the middle and top decks, and out 1¾" on the floor. This is a gain of approximately 10% in volume.
4 Aluminum racking systems weight less than wooden systems:

Wooden Item	Quantity/ 40′ Trailer	Weight (lbs.)	Total (lbs.)	Aluminum Item	Quantity/ 40′ Trailer	Weight (lbs)	Total (lbs.)
Wooden Rack	18	87	1,556	Aluminum Rack	12	57	684
Wooden Board	100	25	2,500	Aluminum Board	96	16	1,536
Z-Clamp	12	7	84	Z-Clamp	12	7	84
Load Lock	2	9	18	Load Lock	2	9	18
		TOTAL	4,158 lbs			TOTAL	2,322 lbs.

4,158 lbs.
− 2,322 lbs.
1,836 (44% less weight)

5. Aluminum planking inter-locks making shifting of planks on racks less likely.
6. Eliminates use of nails — resulting in less flat tires, less injury to loaders and drivers, and no split boards

Table 2. Material Costs for Aluminum 3-Deck Racking System.

Item Description	Cost/Item	Quantity 40′ Trailer	Cost 40′ Trailer
Boards	24.50	96	$2,352.00
Racks	108.00	12	1,296.00
Z-Clamps	13.00	12	156.00
Load Locks	45.00	2	90.00
		Total Cost	$3,894.00

Note: The aluminum boards are made to your specifications regarding length. When measuring inside width of trailer, deduct 3½″ for the racking systems; this will give the proper board length.

Tuesday Afternoon, December 9, 1980

The afternoon session was convened at 1:30 p.m. with John P. Sparmann serving as moderator.

Editor's Note: Francis Gouin moderated a group of presentations on techniques to reduce energy use. The following papers by Francis Gouin, D.C. Milbocker, William Devine, James Kyle, and Adrian Knuttel were part of that session.

VEGETATIVE PROPAGATION UNDER THERMO-BLANKETS[1]

FRANCIS R. GOUIN
Department of Horticulture
University of Maryland
College Park, Maryland 20742

Polyethylene film covered propagating chambers have been demonstrated to be effective for rooting cuttings of many species of woody ornamentals (1). These chambers can easily be constructed within existing greenhouses, and when filled to capacity with cuttings, will maintain near 100% humidity with minimum care.

Nurserymen have long recognized the advantages of direct sticking cuttings into individual containers. In addition to saving time, cuttings rooted by direct sticking grow faster and losses from transplanting are eliminated. Plants from direct stuck rooted cuttings develop faster because their roots are never disturbed. However, direct sticking requires 5 to 50 times more space than conventional high-density-sticking methods. The amount of additional space depends on the size of containers being used.

Nurserymen in southern regions have made extensive use of direct sticking because of their longer growing seasons and milder winters, while growers in colder regions must rely on

[1] Scientific Article No. A-2915, Contribution No. 5972 of the Maryland Agricultural Experiment Station, Department of Horticulture.

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heated greenhouse to propagate. As these propagating structures become more expensive to construct, maintain, and heat, the possibilities for adapting direct sticking practices in colder regions become remote. Direct sticking in colder regions can only be accomplished with efficient, low-cost propagating systems.

Recent studies have shown that certain species of woody ornamentals can be rooted by direct sticking during summer and winter months outdoors under thermo-blankets in Maryland (4). Because thermo-blankets maintain a high humidity and reduce the intensity of light, they have all of the properties of polyethylene film covered chambers (1). Their insulating values have also been well documented (2, 3). Furthermore, thermo-blankets can be used on any well drained area, expanding the propagating facilities throughout the nursery especially during the summer months when bottom heat is not necessary.

PROPAGATING PROCEDURES

Studies on rooting semi-hardwood and hardwood cuttings by direct sticking under thermo-blankets have been in progress since mid-1976. In these studies, cuttings have been rooted in 2¼″ (5.6 cm) peat pots in wooden flats, 4″ (1 liter square plastic pots, 6″ (3.4 liter) plastic nursery cans, and in 3″ (0.8 liter) and 6″ (3.4 liter) black plastic planter bags. All studies have been conducted using a relatively sterile potting medium of equal parts peat moss, milled pine bark and sharp sand, expanded shale or horticultural grade perlite. Sufficient dolomitic limestone is added to adjust the pH to near 6.5 and Fritted Trace Elements (F.T.E. 503) is added according to manufacturers recommendations (Robert B. Peter Co., Inc., 2833 Pennsylvania Street, Allentown, PA 18104). To supply nutrients for developing roots, Osmocote 18-6-12 (Sierra Chemical Co., 1001 Yosemite Drive, Milpitas, CA 95035) was either incorporated into the potting mix at one half recommended rate or applied as a top dressing at recommended rates either immediately after the cuttings were stuck or after the cuttings rooted.

Summer propagation. Summer propagation studies were nearly always initiated in July using a variety of ornamentals: *Jasminum nudiflorum* Lindl., *Forsythia* X *intermedia* Zab., *Viburnum rhytidophyllum* Hemsl., *Ajuga reptans* L., *Hedera helix* L., *Pachysandra terminalis* Siebold & Zucc, *Vinca minor* L and numerous cultivars of *Rubus*. All terminal semi-hardwood and softwood vine cuttings were pruned to a uniform length of 6″ (15 cm). *Ajuga* was propagated from divisions without roots, and *Pachysandra* cuttings were pruned to a uniform length of 4″ (10 cm). The cuttings were stuck as shallow as possible generally 1″

(2.5 cm) deep, and thoroughly irrigated to saturate the soil and the ground beneath. Quarter inch (0.64 cm) microfoam (E. I. duPont deNemours & Co., Inc., Wilminton, Delaware 19898) was laid directly on top of the cuttings with all edges resting on the ground. White copolymer (4 mil) was then laid over the microfoam and sealed to the ground on one side with gravel and on the remaining 3 sides with pieces of pipe and boards (Figure 1).

The cuttings beneath the thermo-blanket were checked weekly and watered when necessary. Depending on species, rooting generally occured from 1 to 6 weeks. *Ajuga* rooted within 1 week while *V. rhytidophyllum* required 6 weeks to root. Rooting was determined by pulling gently on each cutting. If all but a few cuttings appeared rooted, the cuttings were allowed to remain under the thermo-blanket for an additional week after which time the thermo-blanket was either removed or the plants were moved into a growing area.

Winter propagation. Winter propagation studies were initiated in November using cuttings of *Juniperus horizontalis* Moench 'Wiltonii', *Ilex crenata Thumb.*, *Prunus laurecerasus* L., and *Pyracantha rogersiana* (A.B. Jackson) Bean (Syn.:) *P. crenulata* var. *rogersiana* (A.B. Jackson). Terminal hardwood cuttings were cut to a uniform length of 6″ and the base treated with 0.8% I.B.A. (Hormodin #3, Merck Chemical Division, Merck and Co., Inc. Rahway, N.J. 07065) prior to sticking. To eliminate the need for watering and to protect from loss of water, all winter propagation studies were conducted using sealed thermo-blankets. The sealed chambers were prepared by laying 4 mil, 10 ft. (3 meters) wide, white copolymer on the ground and covering the middle 3¼′ (1 meter) propagating area with a thin layer of pea gravel. Rubberized heating pads (Famco Electric Co., Progrow Supply Corp., Butler, WI 53007) were laid on top of the gravel. The containers filled with medium were placed directly on top of the heating pads and the cuttings were stuck. The cuttings were thoroughly watered and additional water was added to partially submerge most of the gravel. Quarter inch microfoam was then laid directly on top of the cuttings with all of the edges coming in direct contact with the gravel. The edges of the white copolymer sealing the bottom were then rolled together over the microfoam and sealed using pressure sensitive tape (Figure 2).

Temperature of the media were maintained at 80°F (22°C) until most of the cuttings had rooted. Time of rooting was estimated by observing similar cuttings rooting under intermittent mist in a greenhouse. When most of the cuttings in the greenhouse had rooted, media temperatures under the thermo-blankets were reduced to 45° F (7°C). The cuttings under the thermo-blanket were left undisturbed until mid-March when they were uncovered.

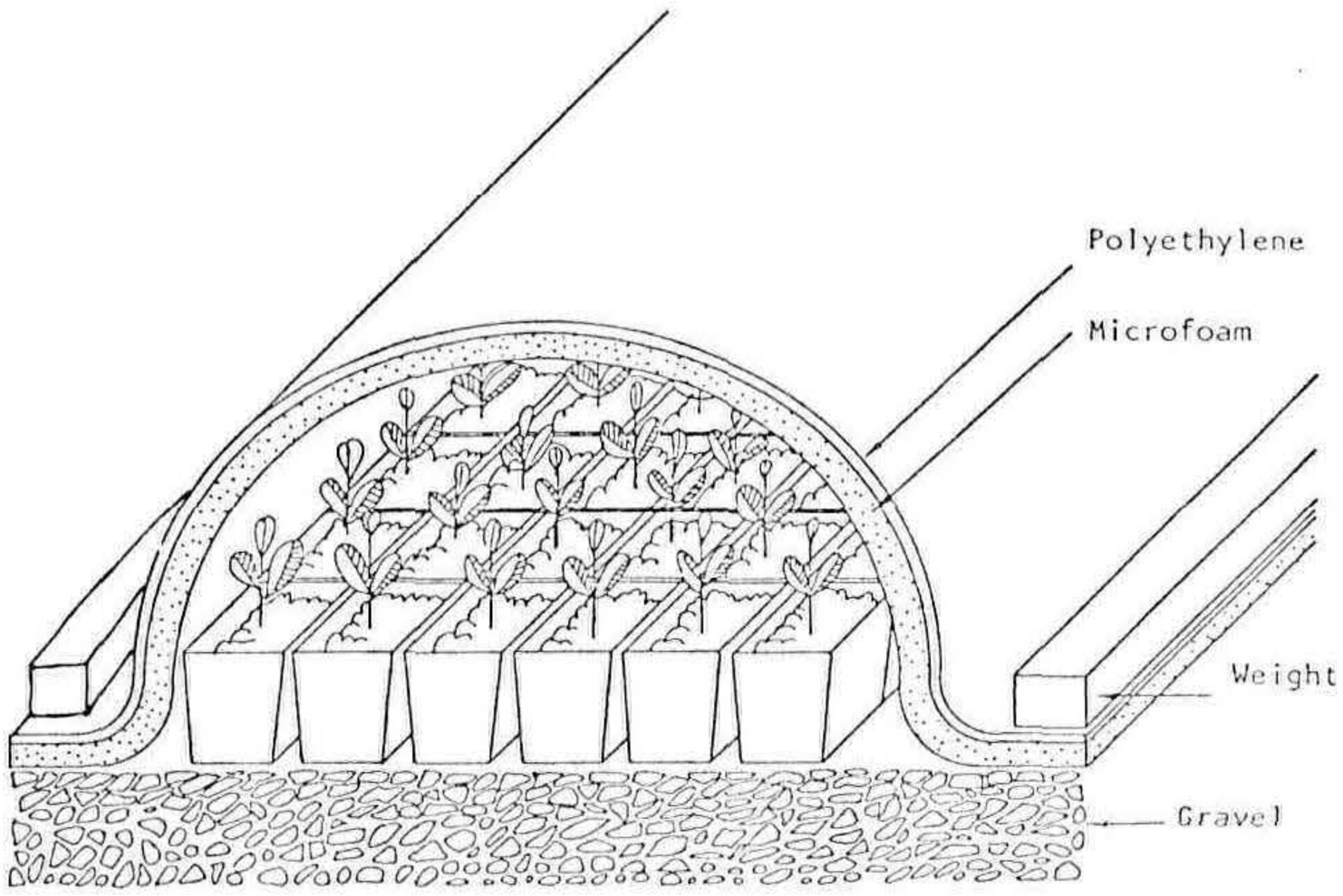

Figure 1. Summer propagation thermo-blanket using white polyethylene cover over ¼" microfoam laying on top of the cuttings stuck in 4" plastic pots. To insure adequate drainage, gravel is placed on top of existing soil. The blanket should be checked weekly for adequate moisture.

RESULTS AND CONCLUSION

To this date all studies have demonstrated that all species tested can be rooted outdoors under microfoam thermo-blankets. Bottom heat is essential for winter propagation but not for summer propagation (4). By using white copolymer over the microfoam, cuttings can be rooted outdoors in full sun. Positioning the thermo-blanket under partial shade has not been beneficial.

Although the winter moisture sealed thermo-blanket system was effective in retaining adequate moisture for rooting and growth for 4½ months, it made periodic inspection of cuttings almost impossible. Should something happen under the thermo-blanket during and/or after rooting, it would not become evident until after the plants were uncovered. Because this potential problem exists, it is highly unlikely that this sealed chamber technique would be acceptable for most propagators. Good propagators like to watch their rooting cuttings periodically.

For winter propagation it is recommended that a bottom copolymer liner be placed under the heating pads or cables with a thin layer of gravel between the two. The bottom coplymer will prevent the downward movement of water and keep the water near the heating pads or cables to be evaporated into the atmosphere of the chamber and to condense on the under surface of the microfoam. When using a copolymer bottom liner the same covering technique, used for summer propagation can be utilized in winter. Preliminary studies have shown that cuttings need only be watered every 2 to 3 weeks even when rooting media tem-

peratures are maintained at 80°F. After the cuttings have rooted and temperatures are lowered to 45°F, the loss of water from under the thermo-blanket is negligible.

Studies are now in progress to measure growth differences between plants propagated during winter months under the thermo-blanket in 1 liter and 3.4 liter containers and plants propagated in a greenhouse. After rooting, the greenhouse-propagated cuttings will be transplanted into liter containers and later shifted into 3.4 liter containers for growing on. Although growth differences have been observed in earlier studies, they have never been evaluated. To facilitate covering and uncovering, portable, inexpensive low quonset type structures, scarcely tall enough to accommodate containers and cuttings, are also being evaluated.

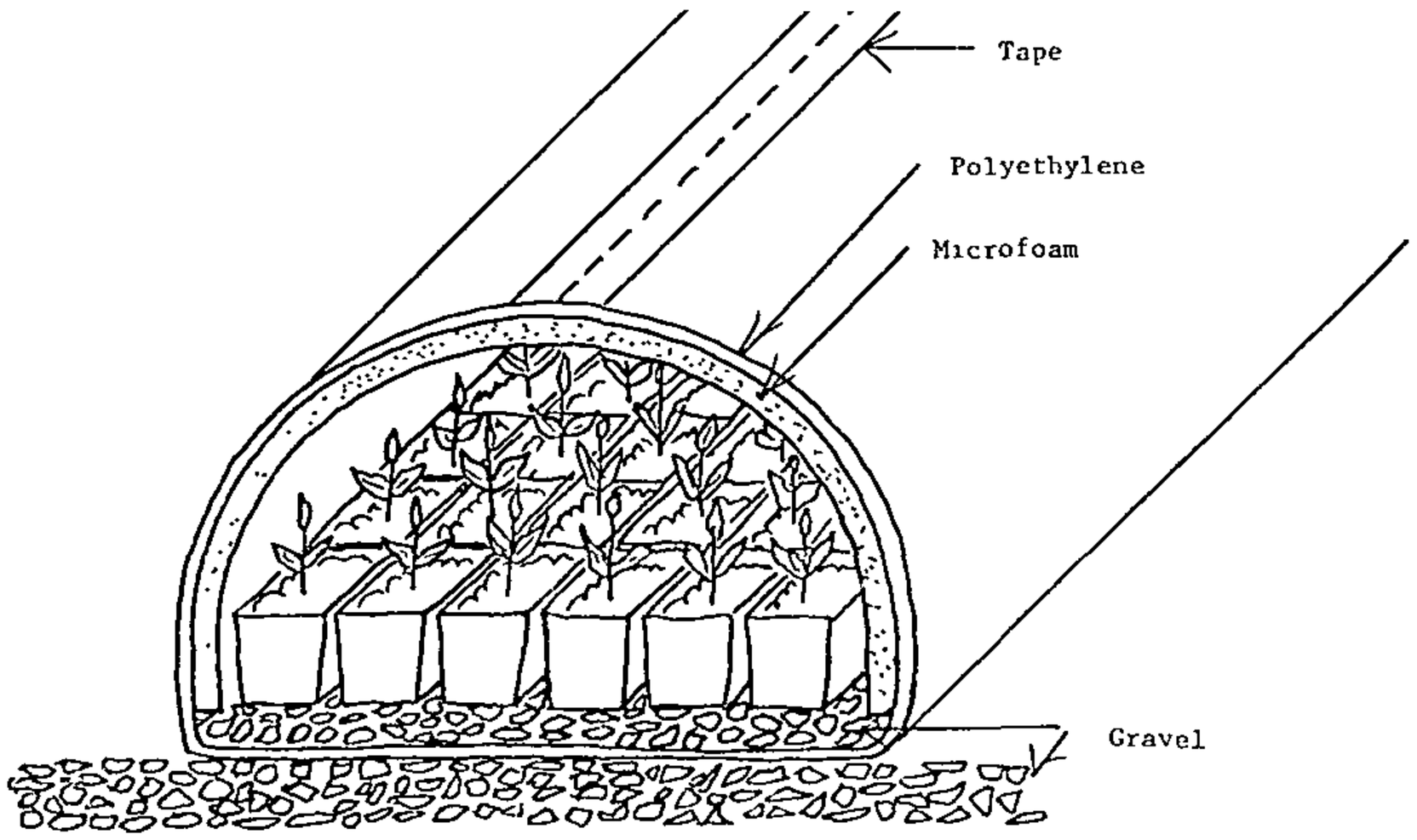

Figure 2. Moisture seal thermo-blanket using a single sheet of white polyethylene extending under the 4″ plastic pots and gravel and over the ¼″ microfoam and sealed on the ends and across the top with pressure sensitive tape. One thorough irrigation in the fall after sticking cuttings will maintain adequate moisture all winter long.

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REDUCING ENERGY REQUIREMENTS WITH VENTILATED HIGH HUMIDITY PROPAGATION

D.C. MILBOCKER

Virginia Truck and Ornamentals Research Station
Virginia Beach, Virginia

Ventilated high humidity propagation is a system in which ambient air is continuously humidified and circulated over cuttings to prevent their wilting. Rooting of cuttings with this system has been observed to be approximately equivalent to intermittent mist with bottom heating. The objective of this report is to show that the energy requirements of ventilated high humidity propagation are smaller than for intermittent mist with bottom heating. Two types of energy are considered, the efforts of the propagator as well as the energy required to operate the equipment.

Intermittent mist systems require misting nozzles spaced to provide overlapping mist patterns over the propagation bed. The better quality systems operate at pressures approaching 100 lbs psi (690 kPa) and require 5 to 10 nozzles per 100 sq ft (9.3 m^2) of bed area. Satisfactory nozzles must have small holes or deflectors to permit use of slightly larger holes. These nozzles require considerable vigilance for opening plugged nozzles, adjustment and replacement of eroded parts.

The Agritech humidifier (Agritech Inc. Raleigh, NC), while not the only means of humidifying air, is available in models that were constructed for ventilated high humidity propagation. Each unit humidifies the air for as much as 1000 sq ft (93 m^2) of propagation area and may replace 50 nozzles. These units produce 200 lbs psi (1380 kPa) water pressure from centrifugal force and produce finer droplets through larger orifices than used for intermittent mist. Therefore the system requires little attention other than occasional filter cleaning and flow meter adjustments.

When propagating with the ventilated high humidity system, evaporative cooling of the cuttings and the propagation medium is not a problem. The humid air surrounding the cuttings prevents evaporation. Solar heat is absorbed by the propagation medium and tends to raise the temperature by as much as 7°F (4°C). This temperature difference functions similar to other forms of bottom heating and stimulates early root initiation.

Bottom heating, as used for intermittent mist propagation, requires the installation of electrical heating cables, hot water pipes or hot air ducts. The cost of electrical resistance heating during the period of propagating a crop of cuttings may cost as much as one dollar per sq ft of bed area. Operation of ventilated high humidity propagation equipment for similar lengths of time were calculated to be approximately one percent of that amount.

The energy requirements for ventilated high humidity propagation as compared to intermittent mist with bottom heating are lower both in terms of propagators efforts and equipment energy requirements.

OUTDOOR PROPAGATING AT ANGELICA NURSERIES

WILLIAM DEVINE

Angelica Nurseries, Inc.
Kennedyville, Maryland

The least expensive method of propagating cultivars would be the direct sticking of unrooted cuttings into beds or field rows. With cooperative weather conditions, this will work well with some plants, usually quick-to-root species handled as dormant hardwood cuttings. With the majority of Angelica's production done as softwood or summer cuttings, the procedure becomes a bit more difficult, because success would necessitate some type of watering system to keep the plant tissues turgid during the rooting period. A deep, well drained especially sandy soil might present the proper medium, but since our area has a heavy loam soil, which becomes waterlogged quickly under continuous watering, soil propagation under mist proves unsatisfactory.

Angelica Nurseries took the next most logical step, which was to create raised beds of sand, while providing more than adequate subdrainage, into which cuttings are stuck for rooting from March until September, as proper timing and scheduling permits.

For four years we have been testing and refining our setup in order to observe its potentials and limitations, and have developed a propagating setup consisting of six units, each unit consisting of two side-by-side beds, each bed measuring 6 x 100 ft constructed of salvaged railbed ties, giving a minimum bed depth of 8 inches (Figs. 1 and 2). Each unit has a water line down the middle, with its own solenoid valve and time clock, with the watering applied through nozzles on 30 in. risers spaced at intervals to provide total coverage of the stuck cuttings. Each unit is separated from the next, and the whole setup is enclosed by 6 foot tall reed matting. This effects a reduction in air movement across the sandbeds and moderates the drying effects of wind and wind interference in the nozzle watering pattern; this prevents dry areas and dead cuttings. Each unit, with a spacing of 1¾ inches between cuttings, holds approximately 60,000 cuttings.

At present we are using a salt hay blanket as winter protection for the rooted cuttings to prevent desiccation of narrowleaf evergreens, and stem splitting of deciduous cuttings. As with any covering there is rodent control to contend with. The cuttings

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must be observed closely in early spring so that they can be processed before breaking dormancy.

The potential economic benefits of such a setup would primarily include the elimination of energy usage for winter rooting and storage. It precludes the need for expensive greenhouse structures with plastic or glass coverings. There is less moving

Figure 1. Outside propagating facility at Angelica Nurseries, Kennedyville, Maryland.

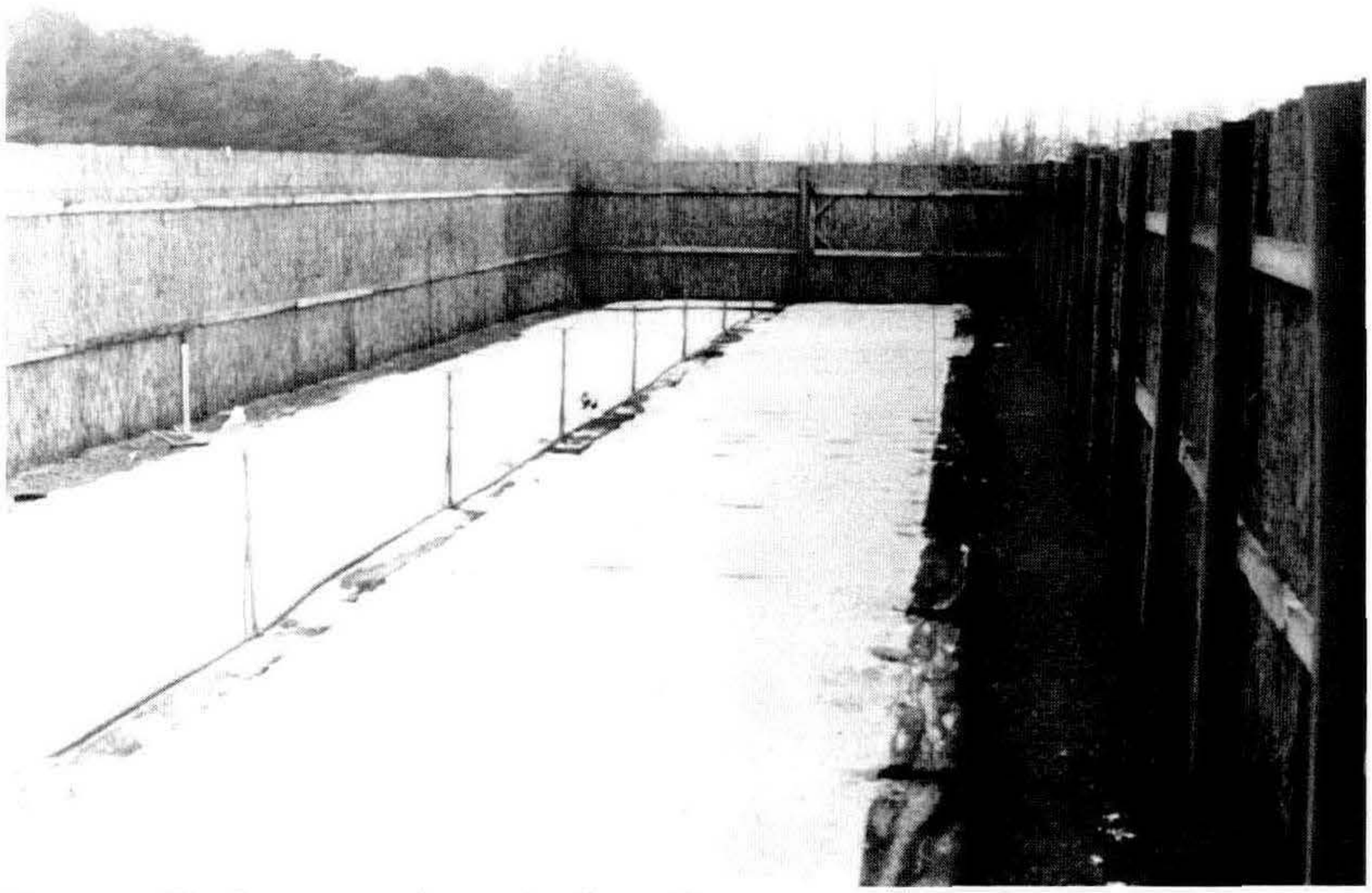

Figure 2. Single propagating unit of outside propagation facility.

and rehandling of cuttings or flats and, if proper drainage is established, no loss from overwatering. It is fairly easy and inexpensive to construct, easily modified for particular requirements, and uses an inexpensive rooting medium. With dormant narrowleaf cuttings we are able to prepare cuttings during the late winter slack period and hold them in cold storage until they are able to be stuck.

This sandbed technique is not new or original. It is just our adaptation of an old principle in outside propagation made more efficient by modern advances in electric solenoid valves and time clocks. More important is that whatever we find can be propagated successfully in our outside sandbeds will use less energy, and be just that much more economical and cost effective to produce. We think that is a worthwhile endeavor and in a positive direction.

ENERGY SAVING PROPAGATION GREENHOUSE

JAMES H. KYLE

Spring Hill Nurseries Co., Inc.
Tipp City, Ohio 45731

In 1972 a poly tunnel 15 x 180 feet was constructed at Spring Hill Nurseries to propagate evergreen cuttings. The house was designed and built to accommodate CPVC plastic pipe for bottom heat. A pit was dug and the house was placed two feet into the ground to cut down on heat loss.

The ½ inch CPVC pipe was placed on 6″ centers and buried halfway in 8 inches of sand. A boiler was installed midway in the house so each end could be controlled separately. Circulating pumps run continuously to give even heating throughout the house. We circulate 140°F water for bottom heat in the house. The boiler water temperature is controlled by thermostats. Details of consturction are available in the 1973 Proceedings (1).

We have used the greenhouse for 6 years to root evergreen cuttings. We have always had good results. In 1979 we discontinued rooting evergreens and switched the greenhouse to perennial production. At the present time, it is full of newly dibbled perennials. These plants respond well to the 70°F temperature. The air temperature will be between 40 and 65°F this time of the year. After establishing, the perennials are moved to a cool house for hardening off.

We feel that submerging the house and insulating the side walls made this a very economical house to heat. During the winters of 1972-73, 1973-74, 1974-75 the house was heated with propane. The three year annual average usage of propane was

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3,762 gallons for a cost of $946.90 per heating season. To cut heating costs in the fall of 1975, it was converted to natural gas and individual records were no longer maintained. The house has a capacity of 204,600 rooted cuttings. Based on the 1972 through 1975 average cost of propane, we rooted 200 cuttings for one penny. Converted to natural gas at our present rate of 32¢ per 100 cubic feet, the cost to heat the house is $1,203,84 per year. Using present rates we could root 166 cuttings for one penny. Natural gas costs 5 times what it did in 1972.

The house is going into the eighth heating season and we have had only two leaks in the plastic pipe. We did have some difficulty isolating one of the leaks and if we were going to install the system again we would put valves on each heating loop.

We have had no problems with expansion of the pipe; however, we would put expansion loops in a new house. When we start the house each fall the pipe moves as much as 18 inches. For this reason we cool the house only once each year.

From our experience, if we were to build the structure again, we would follow the same plan with these modifications:

1) Install a valve at the inlet and the outlet of each heating loop to simplify finding leaks.
2) Install swing joints for expansion within each heating loop to cut down on movement of the heating pipes.

We have used double poly on the house since 1975, but we are not convinced it is a worthwhile investment. Early in the morning during the coldest days of winter, it is not uncommon to see frost on the cuttings while the root temperature is 68 to 70°F.

With the flats of evergreens covering the floor of the house, we find this house cheaper to heat than the same size above ground house with individual unit heaters at each end. It has lived up to our expectations for rooting cuttings.

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TECHNIQUES TO REDUCE ENERGY USE

ADRIAN J. KNUTTEL

Knuttel Nursery Inc.
Warehouse Point, Connecticut 06088

In a paper presented at the 1978 IPPS meeting I described our pithouse propagation facility (1). The building is H-shaped

3,762 gallons for a cost of $946.90 per heating season. To cut heating costs in the fall of 1975, it was converted to natural gas and individual records were no longer maintained. The house has a capacity of 204,600 rooted cuttings. Based on the 1972 through 1975 average cost of propane, we rooted 200 cuttings for one penny. Converted to natural gas at our present rate of 32¢ per 100 cubic feet, the cost to heat the house is $1,203,84 per year. Using present rates we could root 166 cuttings for one penny. Natural gas costs 5 times what it did in 1972.

The house is going into the eighth heating season and we have had only two leaks in the plastic pipe. We did have some difficulty isolating one of the leaks and if we were going to install the system again we would put valves on each heating loop.

We have had no problems with expansion of the pipe; however, we would put expansion loops in a new house. When we start the house each fall the pipe moves as much as 18 inches. For this reason we cool the house only once each year.

From our experience, if we were to build the structure again, we would follow the same plan with these modifications:

1) Install a valve at the inlet and the outlet of each heating loop to simplify finding leaks.
2) Install swing joints for expansion within each heating loop to cut down on movement of the heating pipes.

We have used double poly on the house since 1975, but we are not convinced it is a worthwhile investment. Early in the morning during the coldest days of winter, it is not uncommon to see frost on the cuttings while the root temperature is 68 to 70°F.

With the flats of evergreens covering the floor of the house, we find this house cheaper to heat than the same size above ground house with individual unit heaters at each end. It has lived up to our expectations for rooting cuttings.

LITERATURE CITED

1. Kyle, J.H. 1973 New propagation house using plastic pipe bottom heat. *Proc. Inter. Plant Prop. Soc.* 23:247-250.

TECHNIQUES TO REDUCE ENERGY USE

ADRIAN J. KNUTTEL

Knuttel Nursery Inc.
Warehouse Point, Connecticut 06088

In a paper presented at the 1978 IPPS meeting I described our pithouse propagation facility (1). The building is H-shaped

and constructed below ground which I feel helps to moderate the temperature. Additional energy savings are obtained by using 3 layers of plastic on the roof.

Today I would like to discuss the economics of heating our pithouse. There is a choice of 5 energy sources: wood, coal, oil, gas, or electricity. Natural gas, if available, would be more economical than oil at this time; however, we don't know what the price will be in the future. Wood needs a lot of attention, especially during the night, so I do not find that practical for my propagation house.

Coal is for me the most practical heat for a propagation house. I use an upright burner, brick line of cast iron, which holds 100 lbs of coal. I use coal in combination with electric cables in the beds. I bought coal in bulk at $72.00 a ton. The price expressed in energy units is ⅓ the price of oil. I would suggest heating the propagation house with coal to about 65°F and let electric cables in the beds bring the temperature up to the desired range (in my case 73°F). I still have my oil heat as a back up, since that was originally installed.

Having a propagation house in the ground and switching from oil heat to a combination of coal and electric cables is saving me up to 75% in heating cost.

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1. Knuttel, A.I. 1978, Oil savings in pithouse rooting of rhododendron and laurel cuttings. *Proc. Inter. Plant Prop. Soc.* 28:516-517.

PETER VERMEULEN: Question for Bill Devine. Could you describe your climatic conditions for us? I am particularly interested in temperature.

BILL DEVINE: In 1976 we had the ground freeze to 3 feet. The soil which was covered with 8 inches of straw between 2 plastic sheets did not freeze.

PETER VERMEULEN: Any rodent problems.

BILL DEVINE: Yes, you have to use poison.

PETER ORUM: Question for Adrian Knuttel. Why not use the coal to heat water? We find that it costs about 5 times as much to use electric heat as hot water heat.

ADRIAN KNUTTEL: Yes, you are right. However, you must remember that we are only raising the temperature 5 to 10°F with the electric cables in the beds. The electricity is only on for a very short time. This is a very inexpensive method for heating when you consider that it probably would cost $2,000 to buy a coal hot water boiler.

GRO-PLUG SYSTEMS AND THEIR PRACTICAL APPLICATION IN GROWING ORNAMENTALS

THOMAS S. PINNEY, JR.

Evergreen Nursery Co., Inc.
Route 3, 5027 Ct. TT
Sturgeon Bay, Wisconsin 54235

Gro-Plugs® is the registered name we are using for our tube culture production. We have worked with a tube system for many years in our birch program. Several years ago we began experimenting with other woody seed-propagated ornamentals. Presently we have grown crops of *Abies concolor*, *Picea pungens* 'Glauca', *P. glauca* 'Densata', *P. omorika*, *Pinus mugo* (ENCI), *P. nigra*, *P. sylvestris*, *P. ponderosa*, *P. strobus*, *Tsuga canadensis* and *Thuja occidentalis*. Usually 4 months is required to produce Gro-Plugs® seedlings ready for transplanting in our own fields or for sale.

SEED

Selection. Seed selection is of paramount importance as it contains the genetic basis for each plant. In some cases we have been able to establish our own seed orchards and carefully rogue out undesirable plants. We purchase seed from many places in the United States as well as from Europe and Japan. Over the years we have carefully selected, through a process of evaluation, consistently reliable seed sources. We try to purchase from suppliers who are specialists in particular species, as they can often give us valuable information.

Testing. When seed is received from any supplier, including ourselves, we assign it a lot number and record all pertinent information. We store our seeds in a refrigerated cold storage at 35°F. Approximately two months prior to using the seed, we do a germination test on each lot number. One hundred seeds are counted out and placed on a moistened paper towel which is placed inside of a rigid clear plastic box with a tightly fitting cover. The plastic box containing up to 8 individual tests is placed in our germination chamber. Each germination chamber is equipped with 5 shelves and uses cool white fluorescent tubes as a source of light and heat. The ballasts have been removed to the outside of the box where the heat is dissipated into a workroom. The temperatures are maintained between 75 and 85°F on the surface of the towel. Germination results are recorded after 1, 2, 3, and 4 weeks. Any stratification requirements are fulfilled prior to placing the seed on the towel. From the results we then determine the amount of seed to be used per flat in order to obtain the desired seedling density.

Seeding. Seeds are sown at the proper density to obtain approximately 1,000 seedlings per standard 28 × 54 cm flat. Either fine perlite or vermiculite is used as the medium. Captan and Benlate are used as preventative fungicides. Each flat is covered with clear plastic and placed in the germination chamber under conditions previously described. Bottle thermometers which have been calibrated to a standard unit are inserted through the plastic into the medium so the temperature can be monitored.

Germination. Germination begins within a few days and at this point the plastic is immediately removed and the flats are misted several times a day. Within a week to 10 days the radicles are of sufficient length for transplanting.

PLUG TRANSPLANTING

Media. The media is formulated on a basis of 50% fluffed Canadian peat moss with a pH of 3.8 ± 0.2, 25% coarse perlite, and 25% coarse vermiculite. The pH is adjusted to the proper level for the particular species being grown by using varying amounts of calcium carbonate and dolomite limestone. The pH after equilibrium runs between 4.8 ± 0.2 for many of the conifers and 6.2 ± 0.2 for *Betula* species. We also add calcium nitrate, treble superphosphate, and potassium nitrate as standard amendments. Minor elements are added in some cases in the form of Micromax and GU-49 (iron).

Our standard batch size is 0.89 yds^3. This allows us to use the peat, perlite, and vermiculite in full bag amounts. The peat is purchased in 6 ft^3 bales and, when fluffed, makes 12 ft^3. The perlite and vermiculite are obtained in 3 ft^3 bags. By using one fluffed bale of peat, 2 bags of perlite and 2 bags of vermiculite we obtain a batch contining approximately 24 ft^3 of material which is equal to 0.89 yds^3.

Table 1 refers to a standard batch of our media. The pH has been adjusted by the full increment of calcium carbonate and dolomite limestone.

Table 1. Components contained in a standard media batch[1]

Canadian peat (fluffed)	—	12	ft^3
Perlite, coarse	—	6	ft^3
Vermiculite, coarse	—	6	ft^3
Calcium nitrate	—	102	grams
Treble superphosphate	—	306	grams
Potassium nitrate	—	204	grams
Calcium carbonate	—	1631	grams
Dolomite lime (Zone 80-89)	—	1223	grams
GU-49	—	453	grams
Micromax	—	399	grams

[1] A standard media batch equals 0.89 yds^3

Table 2. pH at equilibrium when various increments of the standard calcium carbonate and dolomite limestone are used.

Increments	*pH ± 0.2*
1.50	6.2
1.00	6.0
0.75	5.7
0.50	5.5
0.33	5.0
0.25	4.8

Each batch is adjusted to the desirable pH for specific crops by varying the amount of calcium carbonate and dolomite lime from the standard increment. Table 2 shows the pH at equilibrium when various increments of the standard calcium carbonate and dolomite limestone are used. It is important to understand that the pH at equilibrium will vary from batch to batch and we have shown this by a plus or minus 0.2 variance. A technician who has standardized her practices with our consultant in California monitors the pH using a pH meter.

Trays. Over the years we have worked closely with Growing Systems, Inc., 2950 North Weil Street, Milwaukee, Wisconsin 53212, in developing the tray we are presently using. The tray is called a "Groove Tray" because the individual cells consist of twelve convex sides. The diameter of the top opening is 4 cm tapering to 2 cm at the base. The height is 6 cm. There are 73 cells in an individual tray which measures 51 × 30 cm. The trays are vaccum formed, using black PVC for our use. Through careful handling, more than one use is obtained. Each plant has 21 cm^2 of space or approximately 44 plants per ft^2.

These cells are specially designed to prevent root circling. The large opening at the base is used for air pruning. In the nursery industry it is not necessary to have the long tube which is normally used in the forest industry. Irrigation is available to us and present planting machines are easily adapted to the shorter tube.

The individual trays are filled with media through the use of a flat filler. The trays are then placed in a specially designed pallet. The pallet holds 12 trays or 876 plants. The pallets are so designed that the bottom of each cell is exposed to air for the root pruning process.

Transplanting. The pallets containing the trays filled with media are then transported by dolly to the work area where individual trays are removed and placed at optimum working level for the individual transplanter. Compaction and moisture content of the media must be proper to prevent the media from falling out of the large hole at the base and to provide an optimum moisture level for the tiny new radicle. This comes only with experience.

During transplanting all crooked, weak, and otherwise undesirable plants are discarded. The radicle of the newly germinated seedling is carefully dibbled into the medium. Care must be taken not to bend, twist, or in any way deform the radicle during this cruical operation. The medium is then firmed to a point where the radicle will not push out of the medium as it begins to grow nor to a point where the structure of the medium is destroyed. Ther performance and quality is constantly monitored through our system of reasonable expectancies. The trays are then replaced in pallets and the pallets moved to the greenhouse. Two people can easily handle one pallet.

Culture. The individual pallets are set on cement blocks which form the bench. The edge pallets are skirted with microfoam and black plastic.

Media temperature is maintained between 55-60°F, while the air temperature varies from 35° to 80°F. Bottom heat is provided by hot water heat under the pallets.

Water and a constant fertility program is provided through the use of a variable speed boom and T-jet nozzles. The pH of the water is adjusted to 6.0 ± 0.2 through injection of concentrated sulphuric acid into the water. The fertilizer water, as it is applied, contains between 150-300 ppm of N, 28-88 ppm of P and 100-130 ppm of K. Minor elements are either added through amendments such as Micromax to the medium or in the fertilizer water. Each crop varys in its fertility requirements. The pH and salinity levels are monitored each week on major crops during the growing season. If any problems arise, our technician supplies our consultant with pertinent information so that he can advise us as to the best course of action. If the salinity level rises too high we simply switch to an 80% concentrate level or occasionally to clear water for a week. We are much more concerned about trends rather than the absolute numbers.

Photoperiod is controlled through the use of incandescent lights mounted on a boom. It's on-off cycle is controlled by a photoelectric cell. A timer may be installed in the circuit if so desired. A trip counter monitors the boom travel during the night and is checked each day to see that the correct number of trips have been made. Each plant receives a minimum of 30 foot candles of incandescent light for approximately 4% of the night hours, with a minimum of one lighting period each 30 minutes.

A preventative fungicide program is used. Presently Captan and Benlate are the main ingredients. The houses are baited for mice and other pests are monitored and sprayed or dusted accordingly. We employ an integrated pest management concept. Good housekeeping techniques and sanitaiion are an integral part of our entire Gro-Plug® system.

The greenhouses are covered with two layers of clear polyethylene and air inflated. A third layer of clear plastic is used inside to drain condensation to the edge of the greenhouse. During the summer months the plastic is removed and the houses are covered with shade cloth giving approximately 35% shade. A fan-jet is employed to ensure good air movement and acts to circulate the hot air heat supplied from an LP heater. The thermostat on this heater is set at 35°F and only supplements the air temperature during very cold nights when the bottom heat may not prevent the tops from freezing. It also acts as a back up system to the hot water heat. The standard exhaust fans and motorized louvers are used to cool the greenhouses during the time the plastic is on.

The plants remain in the greenhouses for four to six months after which they are ready to transplant to the field or sell. A given greenhouse may be used for two or three crops per year depending upon th amount of energy one may wish to consume. We start our first crop approximately February 15th and it can be moved outside in mid-May after the danger of frost is over to finish its growth. It is ready for transplanting or selling between June 15th and July 1st. In mid-May the second crop is started in the greenhouse under plastic. After approximately one month the plastic is removed and the shade cloth put in place. The crop is finished by September 15th, or four months, since the temperatures are warmer at this time of year. We field transplant this crop ourselves or hold some of it over the winter for sale the following spring. We do not usually sell Gro-Plugs® in the fall unless the customers are far enough south so that root generation can occur and proper winter conditioning take place. A third crop may be started in the greenhouse on September 15th and run thru February 15th; however, this crop is expensive as it consumes considerably more fuel.

Costs depend greatly on survival percentage. Currently at 85% survival, the cost per plug is approximately 35¢. This includes all fixed and variable costs at a production level of 900,000 units per year. All amortizations are included except research in prior years.

SELLING/FIELD TRANSPLANTING

Selling. Because the 73 cell trays are relatively inexpensive, they can be used as a shipping container. Currently the PVC costs approximately 90¢ and the polystyrene 55¢ per tray. We have designed a shipping box for UPS, or the trays may be delivered in our own truck. It is important to educate the customer as to the proper handling of Gro-Plus®. It is critical that the plug is transplanted when the roots are active and at a time

when they will develop sufficient root systems prior to winter. They must be subjected to the normal fall photoperiod and temperature conditioning at their new locaiton prior to winter.

Field Transplanting. In our own operation we do not harden off the plants prior to transplanting as we want a large number of white active roots on the surface of the plug. We transplant all of our plugs with a modified mechancial transplanter at spacings varying from 8½" to 28" on the square. We design our production schedules in the greenhouse so that we are actually planting from May 1st through August 15th. Root regeneration and movement out into the surrounding medium occurs within 24 to 72 hours if the roots are active. During the cirtical first few days we use a mist blower several times a day depending on weather conditions to reduce the stress on tops of the plants. We are careful not to overwater new plants so as to inhibit root regeneration. Sample plants are dug every few days to monitor moisture and root development. The herbicide program varys during the course of the season and the physiological condition of the plant at the time of transplanting. Pests are monitored through an integrated pest management program.

Survivability was between 95-99% this past season. By the end of the summer the conifer plants are the same size and of better quality than our standard 3-year transplants (2-1) of the same species. The Gro-Plugs® are 4 to 7 months while the 2-1 are 3 years old. Furthermore, the quality of the Gro-Plug® is much more consistant, and its performance the following year excels that of the standard 2-1.

Deciduous plants such as *Betula* respond very well. A seed planted in late March and run through the Gro-Plug® system, being transplanted into the field in early June, reaches an average height of 2 to 3' by fall with excellent caliper and branching habit.

SUMMARY

Over the past 10 years we have developed a Gro-Plug® System which has become an integral part of our propagation methods for seedling-grown conifers and birch. The advantages for us appear to greatly outweigh the disadvantages. The major disadvantage is lack of technical knowledge and skilled people to perform the intricate tasks involved in producing a quality crop on a consistent basis at a reasonable price. Gradually this disadvantage has been overcome as we have learned by experience, and the percentage survival in the greenhouse has steadily climbed.

Some of the major advantages to us are that we are able to more quickly respond to market needs as our growing time is

greatly reduced. We make more efficient use of seed which is in short supply, such as our strain of *Pinus mugo* (ENCI). Crops which are not hardy in our area can be grown and sold in markets further south. Plants with low pH requirements can now be grown. Our transplanting work-load has been spread over the entire summer rather than concentrated in the busy spring months. Survivability is consistently excellent and predictable. Quality is improved through grading standards at the time of the initial transplanting and carries on into the field production. Finally, the Gro-Plus® system is replacing a considerable amount of our seed bed production and bare-root transplanting.

RALPH SHUGERT: Can you put *Taxus cuspidata* through this system?

THOMAS PINNEY: Yes. The key is getting good seed.

GREENHOUSES HEATED FROM POWER STATIONS[1]

RUSSELL STANSFIELD

Northern States Power Co.
414 Nicollet Mall
Minneapolis, Minnesota 55401

In the early 1970's, Northern States Power Company (NSP) began to explore methods of utilizing for beneficial purposes the large amounts of heat rejected by the condensers of electric generating plants. At that time all of NSP's plants had cooling systems which were designed for "once-through" cooling, that is, water was taken into the plant from a river, used to condense steam, and then was returned to the river. Minimum temperatures of condenser discharge water at plants designed for this type of cooling range from 50°F to 60°F.

Since it would be extremely costly to remove significant amounts of heat from water of this temperature, it was not until a "closed cycle" cooling system, such as the one designed for the Sherburne County plant (SherCo), came into the picture that the Company could seriously consider developing beneficial uses of power plant cooling water. Minimum temperature of SherCo's condenser discharge water is 85.F. Sometimes the temperature during the heating season can be as high as 95° to 100°F. In a closed cycle system, cooling water is circulated from the power plant condenser through cooling towers, where the heat is removed by evaporative cooling. The cooled water is returned to the condenser where the cycle is repeated.

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[1] Editor's Note: the paper by Russell Stansfield was presented by Dr. Harold Pellett, University of Minnesota, St. Paul, Minnesota.

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Most modern electric generating plants are 35 to 37 percent efficient. This means that for every three units of energy input from coal, natural gas, oil or nuclear fuel, only one unit is actually converted into electric energy. By using a portion of the wasted energy for beneficial purposes, such as heating of greenhouses, a more efficient use of natural resources can be realized.

Cooling water leaves the condensers of the power plant, where it is pumped to the cooling towers. The temperature is lowered 29°F, in the case of SherCo, with the cooled water returned to the plant. Prior to entering the cooling tower, a small protion of warm water is diverted to greenhouse structures where the heat is removed for a beneficial purpose — heating the greenhouse — after which the cooled water is returned to the power plant.

The plot plan of the Sherburne County generating plant is located in the village of Becker on U.S. Highways 10 and 52, 45 miles northwest of the Twin Cities. A 65 acre sludge pond has been built. The warm water greenhouse complex is located approximately 1,500 feet south of the Unit II cooling tower.

The 340 acre tract just west of Becker and north of the generating plant site is owned by NSP. This acreage has been made available to the University of Minnesota for a long-term, no-cost lease for the location of the Sand Plain Agricultural Experiment Station. The Agricultural Experiment Station and NSP were joined by the United States Environmental Protection Agency in the Warm Water Greenhouse Research and Demonstration Project. Construction of the greenhouse began in the fall of 1975.

The type of greenhouse selected for the project is a pipe-supported, gutter-connected double-polyethylene structure, manufactured by the X.S. Smith Company. Structures similar to this were introduced in the United States by a Dutch greenhouse operator, Aart Van Wingerden. Since that time, many acres of this type of structure have been built in this country. The bows of the roof, connected at the gutters, are covered with a double-layer of 6 mil polyethylene. The layers are separated by air from a blower powered by a tiny electric motor. The resulting air space provides an insulating effect. In fact, double-layer greenhouses have 30 percent less heat loss than single-pane glass structures. NSP workmen built the structure which consists of 14 bays, each 17' × 96', for a total of more than 22,000 square feet, or slightly more than one-half acre.

In the north end of each bay, a centrifugal air handling unit has been installed. These heat exchangers are manufactured by Trane, of La Crosse, Wisconsin. This equipment is readily available from Trane, McQuay, and other manufacturers. The heat

transfer from warm water to air is accomplished by drawing air across finned-tube coils. Thirty-foot polyethylene perforated tubes distributed the warmed air throughout the structure.

Another facet of the heating system involves soil warming. The soil heating system consists of 1" polyethylene pipes buried 12" below the soil surface on 2' centers. Warm water is circulated through this network of pipes to warm the soil and enhance crop growth. Power plant warm water is not used for irrigation purposes. The soil warming system is a closed loop, as are the finned tube heat exchangers. The water in the heating systems is returned to the power plant. The control center, specifically designed to aid in trouble shooting is located in the headhouse.

University of Minnesota scientists in the fields of plant pathology, horticulture, soil science and agricultural engineering provided expertise to solve problems and to keep the greenhouse productive. The warm water heating system is designed to provide all of the heat for the greenhouse, even on the coldest winter days. Minimum temperature at night can be maintained at 60°F. The coldest day during the project was on January 9, 1977, when the outside temperature dipped to −42.6°F. Inside the greenhouse satisfactory temperature was higher than design.

The greenhouse atmosphere was enriched by the use of CO_2 generators. Burning propane to create CO_2 increases yield and quality of both vegetables and flowers.

Since the project was started before the power plant was completed, warm water was simulated with electric boilers. These are now used for standby purposes.

SherCo Unit I went on line in April, 1976. Each unit of SherCo produces 680 megawatts. Each unit has its own cooling tower which functions independently, with no connection to the other unit. Work began in connecting the greenhouse to the power plant in the fall of 1976. PVC irrigation type pipe (12″) was used to conduct the warm water from the power plant to the greenhouse with a second 12″ line to return the cooled water to the plant. The tap for the warm water supply was made in one of the cooling tower risers. One-way distance from the Unit I cooling tower to the greenhouse is 3,500′.

Above grade construction of the 12″ line is steel; the transition to plastic is made just a few feet from the cooling tower. The pipeline is buried at a nominal depth of 5′. Water is returned from the greenhouse to the basin at the bottom of the tower.

The first commercial greenhouse operator, Tom Hermes, built his own greenhouse on NSP property during the summer of 1977. He is presently buying waste heat from NSP, with rates based on the cost of building and maintaining the pipeline plus

pumping charges.

Hermes liked the soil warming system that he saw demonstrated in the research greenhouse so he installed it throughout his own structure. The warm water heat exchangers are very similar to those in the SherCo greenhouse, with some improvements and refinements added. Herme's 1½ acre building is being used to grow roses.

The second commercial operator, again building and financing his own greenhouse, is Tom Lange. Lange grows vegetables, tomatoes, spinach, lettuce and cucumbers in his ½ acre unit, using the nutrient film (hydroponic) technique.

The Company has reserved approximately 50 acres adjacent to the power plant for warm water greenhouse development. With construction for 1980 completed, there are 2.5 acres of greenhouses at SherCo, with more scheduled for 1981. In fact, Tom Hermes has an additional 1.5 acres under construction at the present time. Fifty acres is enough land to support 14 to 15 acres of greenhouses. A pipeline has been built to connect Unit II to the complex, which gives operators two-unit realiability. The Company is pleased with the results of the waste heat project and feels that as the cost of natural gas, propane, and fuel oil continues to rise, the alternative energy in the form of waste warm water will look increasingly attractive.

KEN MUDGE: I was wondering how the cost compares to standard methods of heating.

HAROLD PELLETT: I am not sure of the exact cost; however it is considerably lower than common methods.

KURT TRAMPOSCH: What would happen if you have all those greenhouses tied into this system and it goes down for 6 weeks in February?

HAROLD PELLETT: The first 3 greenhouses built had backup heating systems, so your initial costs are greater. The SherCo system has 2 separate power units so now if one goes down the other can supply the needed hot water.

GRAFTING APPLES

STANLEY M. FOSTER

Greenleaf Nursery Company
Park Hill, Oklahoma 74451

Greenleaf Nursery Company is headquartered approximately 90 miles southeast of Tulsa, Oklahoma, at Park Hill. Our Texas division is located in south Texas approximatley 70 miles southwest of Houston at El Campo. Both nurseries are exclusively

pumping charges.

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producing container grown ornamentals, growing a broad selection of narrowleaved and broadleaved evergreens, trees, and shrubs.

At the present time we at Greenleaf graft 16 cultivars of fruiting apples, crabapples, flowering pears, and fruiting pears. This year we will graft a little over 100,000 trees. Of these grafts, we expect 85 to 90% to be high enough quality to be planted in the field.

Our apple grafting season starts about January 2nd each year. We use the whip or tongue method of grafting on both apples and pears. Preferably, the scion and understock should be of equal diameter. The scion should contain 2 or 3 buds with the first graft cut made in the smooth internode area below the lower bud. This first cut should be a long smooth, sloping cut 1 to 2 inches long, preferably made with one single stroke of the knife. Then a reverse cut is made. It is started downward at a point about ⅓ of the distance from the tip and should be about ½ the length of the first cut. This cut is then matched with an upward cut starting at the crown of the understock. The cuts made at the top of the understock should be exactly the same as those made at the bottom of the scion. The understock and scion are then inserted into each other with the tongues interlocking. It is extremely important that the cambium layers match along at least one side and it is much better if they match on both sides.

After the understock and scion are fitted together, they are held securely in place by ½ inch grafting tape. They are then tied into bundles of 50 and packed in chicken boxes using brown kraft paper as a box liner. Moist shingle-toe or long fiber sphagnum moss is used to cover the roots.

These boxes are then placed in a warm area (70°F) to allow as much callusing as possible before the buds start to swell, forcing us to put them in a walk-in cooler which is kept at 36-38°F. The grafts are then inspected on a weekly basis until they are potted in a 3 inch peat pot and placed in a quonset. They are grown in the quonset until after the danger of frost is over — approximately May 1. At this time they are planted in the field. This procedure allows us to take the losses on our grafts in the quonsets and to send the highest quality plants to the field.

Other than the matching of the cambium layers, sanitation has to be given the highest priority. Our scion wood and understock is washed with clear water and dipped in a fungicide solution before they are sent to the grafters. The grafting knives are dipped in a disinfectant solution after each cut and the grafters are told not to touch the open wounds of the grafts with their hands.

We do not pay piece work on our grafting because we feel

the grafters would try to hurry too much and turn out lower quality grafts Instead, we use close supervison to keep everyone busy and producing high qualtiy grafts.

This program we use on apple grafting is nothing new or fancy, but if done properly, it can produce excellent results. It is directed at one main objective: "Produce the highest quality liner possible at a reasonable economic level."

TOM McCLOUD· *You mentioned leaving a gap in the tape* to look for problems. What problems are you looking for and how do you correct them.

STANLEY FOSTER: One thing we hope to find is a lot of callus growth If none is occurring we will check for proper alignment. You also find mold growing sometimes. In that case we dip them in fungicide and repack That often means that the sphagnum moss was too wet when packed. You can also see fireblight at this stage sometimes. The checking is done on a spot basis.

RALPH SHUGERT· I notice that you were doing both piece root and whole root grafting. Have you checked both ways for survival?

STANLEY FOSTER: Yes, and we basically found no difference.

RALPH SHUGERT. What pear stocks are you using?

STANLEY FOSTER: We use *Pyrus calleryana* only.

VOICE: Do you have problems with your scions rooting?

STANLEY FOSTER. No. We have more problems with the understock sprouting. We control this somewhat by planting them deep.

COST ACCOUNTING TO PROPAGATE PROFITS

PATRICK J. KIRSCHLING

Purdue University
West Lafayette, Indiana, 47907

The principal reason for being in the propagation business is to make a satisfactory profit. A satisfactory profit level does not occur as a matter of chance but is a result of careful management of the activities of the firm. This, of course, includes the controlling of costs and the determination of realistic prices for products and services in line with competition in your market area. Production and sales should be undertaken with full recognition of all costs involved to maintain a profitable business operation.

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As part of a marketing strategy, you may decide to cover all costs on a specific product, but this is a different situation than propagators who do not recognize all costs associated with the product and consequently sell at a price which is not sufficient to cover all expenses. Even though this propagator can't survive in the long run, he can cause problems for his competitors while he is in business

The purpose of this paper is to examine costs in the propagation business and develop a means to allocate these to a particular product. This means finding some simple means of allocating costs of operating a propagation business that will allow growers to price their products for profits.

SITUATION

The propagation business, like most other business enterprises, and the greenhouse industry, is faced with increasing production costs. The cost of labor, materials and energy have forced up production costs and, as a result, prices too have had to increase. However, cost increases are often absorbed by growers who fail to identify and compensate for such increases by raising prices accordingly.

The need to raise prices is inevitable, as inevitable as increasing costs. Yet many times propagators fail to raise prices enough to cover costs or to maintain desired or previous profit margins. The failure to cover costs and/or maintain reasonable profits will surely mean the demise of a propagator's business or the lack of future growth and the slow demise through profit starvation.

What is needed to correct such a situation in most cases are cost records, a planned greenhouse program, and a cost accounting system for the propagator's business. Cost records are the basis of the business and the means of identifying and monitoring business expenses and product costs. A planned greenhouse program is key to the successful propagation business. It quantifies the space resource — square feet of propagation bench — and organizes it into a plan and meshes it with the cost record system. The result is an integrated cost record keeping mechanism linked to the propagation program and space which leads quite naturally toward a cost accounting system that combines all the components that are needed to detemine the elements of total product cost.

ELEMENTS OF TOTAL PRODUCT COST

Elements of total product cost consist of materials, labor, and all overhead services (Figure 1). All of the proportionate share of these costs should be allocated to each particular product.

Direct Materials Cost. Direct materials include cuttings, soil, peat, pots, chemicals, or other supplies which actually become an integral part of the product. It also includes cost items such as sales tax, handling charges, and freight which can be directly applied to a specific product.

Direct Labor Cost. Direct labor cost includes wages, fringe benefits, and payroll taxes for labor and supervision which are directly related to the particular product.

Overhead Cost (Indirect). This category consists of all other costs that are not included in direct costs. Some of these are supervisory salaries, utilities, depreciation, insurance, annual rentals, property taxes, auto and truck expenses, professional services, office supplies, secretarial salaries, and interest expense. Most overhead items are difficult to allocate to a specific product. However, they can be allocated, if you deem it necessary, by developing a cost accounting system to determine the amount for each job.

Direct vs. Overhead (indirect) Costs. Two criteria can be used to tell if a cost should be classified as direct or overhead. Direct costs occur as the direct result of that product. Other costs like insurance, interest, and depreciation are more difficult to tie specifically to a particular product. Overhead costs occur if: (1), it is impossible to allocate a cost item specifically to a product; (2), it is economically unfeasible to allocate the items as direct costs; or (3), the costs are not considered of enough importance to be accounted for as direct costs.

COST ACCOUNTING SYSTEM

The object of any cost accounting system should be to assign all income and expense items to each crop. The components of such a system are:

1 Crop Cost Records
2. Cost Allocation System
3. Rent System
4. Cost-profit comparison

These components are the basis for determining direct material cost, direct labor cost, direct cost, indirect cost, and total product cost (Fig. 1). The cost accounting system then enables the total product price to be determined with reasonable profit and any contingency costs accounted for (Fig. 2). The workings of the above components need to be elaborated.

Crop Cost Record. This consists of a form for each crop or product being propagated and sold. It should indicate the reciepts, labor, material, overhead, and units sold for that crop. The crop should be identified by name and by a crop number (Table 1).

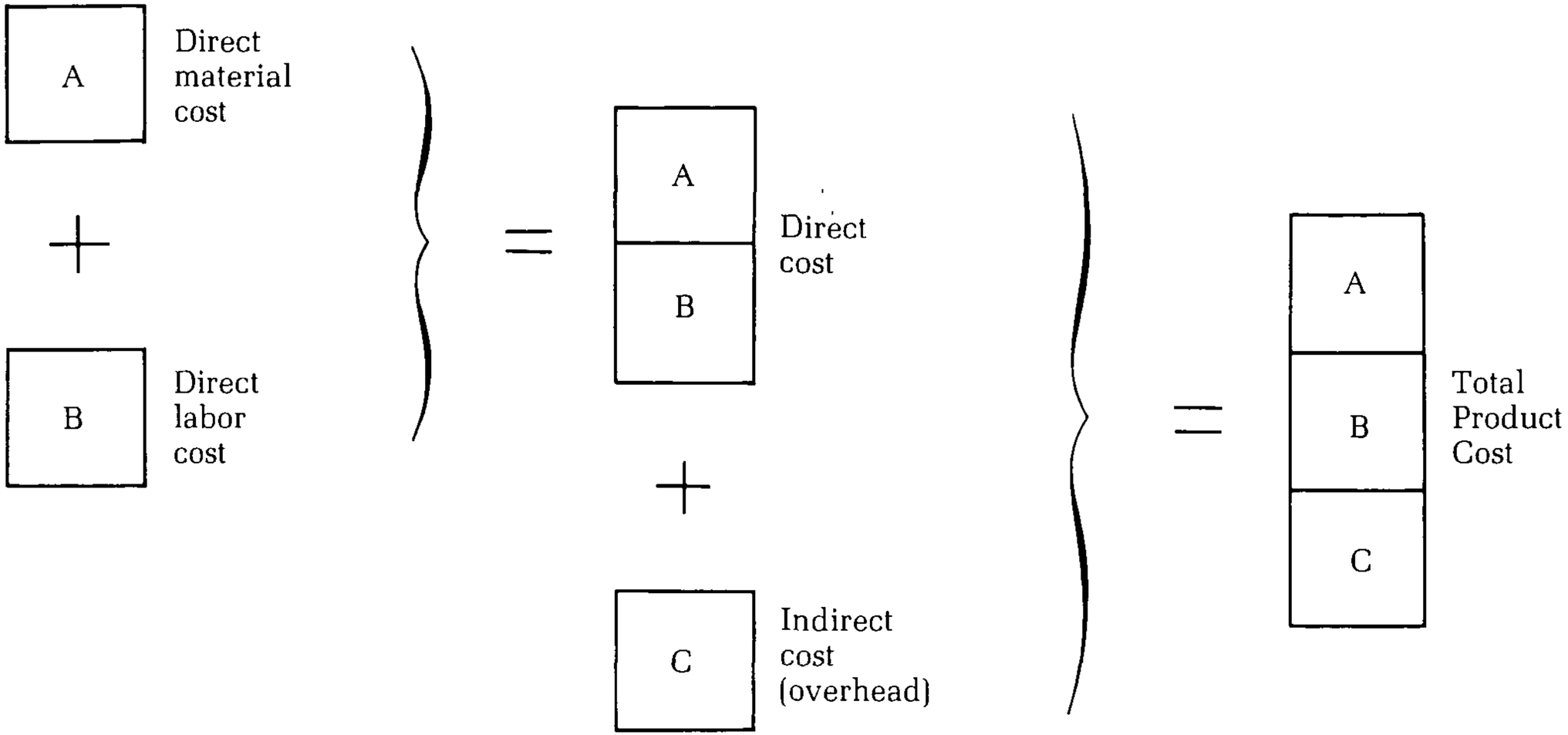

Figure 1. Elements of total product cost

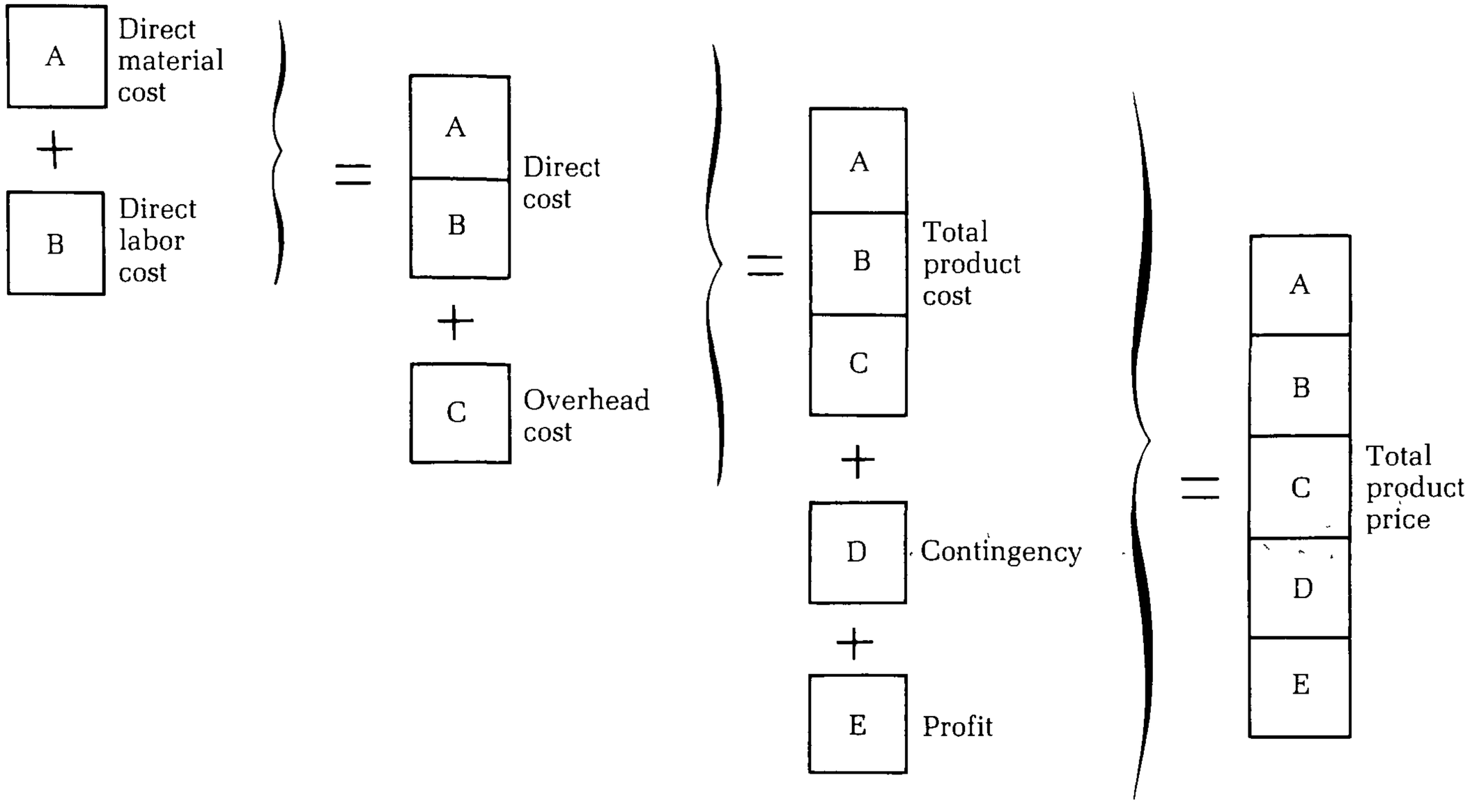

Figure 2. Elements of total product price

Table 1. Crop cost record form

	Crop Azalea			Crop No 5	
Month	Receipts	Labor	Materials	Overhead	Units Sold
Jan	3,000	100 150 200	100 100 50	1,000	6,000
TOTAL	3,000	450	250	1,000	6,000
	−1,700 cost			+250 material +450 labor	
	$1,300 profit			$1,700 cost	
	$\frac{\$1,700}{6,000} = \$0\ 283$ cost each				

Cost allocation system.

Receipts are tabulated and recorded from receivable accounting process. This should be done on a weekly basis. The weekly receipts should then be entered on the crop cost record.

Labor cost should be entered on the crop cost record on a weekly basis The labor cost should be obtained and tabulated from the printed time sheets which each employee should complete. The labor time sheet should be a daily record by crop number with non-crop time allocated to overhead. These time sheets produce weekly crop labor costs (Table 2).

Table 2. Employee weekly time sheet for producing weekly crop costs

NAME	CLOCK #			RATE			DATE
Crop #	1	2	3	4	5	6	7	TOTAL
Mon		4		3			1	8
Tues	6		1		1			8
TOTAL HRS								
TOTAL $								

Materials are entered on the crop cost record from the charge or cash invoices for each crop. General supplies used for many or all crops should go to overhead. Overhead for the crop cost record should be computed and entered weekly. Into this overhead category should be general labor and materials used for the overall production and propagation of crops. The indirect expenses of business, such as utilites, management, etc. are accumulated in overhead to be then allocated to the crops. That allocation procedure should be on a square footage basis of propagation area

Rent system.

Bench space usage is needed on each crop for the allocation of overhead costs. That square footage use by crop and crop number should be obtained weekly by inventorying of all crops by the house, crop, and square foot occupied based on bench and house layout maps (Table 3)

Table 3. Space inventory form

Week Ending_____ Foreman_____

House	Bench	Area	Occupied	Crop	Remarks
3	1	600			
	2	600			
4	1	900			
	2	900			

Cost-profit comparison.

The number of unit sales entered on the crop cost record should be the original estimates of the quantity to be sold and the actual quantity sold based on the receipts. Comparisons should be made between these figures and non-marketable amounts noted.

Crop profit can be computed right on the crop cost record after totaling the weekly and monthly amounts for receipts, labor, materials, overhead, and units sold. Reciepts less costs equal the crop profit. Crop profit divided by the units sold gives the profit per unit. Cost per unit can be obtained in a like manner by dividing total cost by the number of units sold. (Table 1).

This determination of cost and profit is essential for all businesses. Profits are needed to survive and grow. However, a system of cost accounting is need to assign all income and expense items to each crop. That system can be a simplified or a sophisticated system of cost accounting.

It is important to keep accurate records and to have a well-planned greenhouse program. Some growers and propagators work on a guessing basis and yet have been able to operate and show a profit. Because many growers do not know how to arrive at their costs, they have sold their products below their actual cost of production, and ended up taking a loss.

For most propagators the simplified cost accounting system is of value if the grower does not need more detail about labor costs and operating expenses. However, the costs and the benefits need to be weighed before deciding on an accounting system.

The simplified system should be the starting point for all propagators. It offers great benefits and is not costly. The system is composed of employee time sheets which provides payroll and labor cost per crop information. It is the basis for allocating materials cost, overhead cost, and receipts to the crop The results of the simplified system are information on costs, receipts and profits in total and per unit.

A model formula for the simplified accounting system to arrive at unit cost is shown in Table 4 with an example in Table 5.

Table 4. A model formula for the simplified accounting system to arrive at unit costs

Monthly space occupied (inventory by square feet of bench space)	×	Average monthly indirect cost (overhead per square foot of bench) + Depreciation per square foot of bench	×	No of months grown	+	All direct costs for materials (seed, bulbs, plants, and direct labor) = Unit Cost

divided by the number of units produced per crop

The "Greenhouse Plant Cost Estimation Program" on the statewide Purdue Cooperative Extension Service FACTS System uses this type of simplifed accounting system data and formula. It uses a "rent" concept to allocate overhead costs or indirect costs on a square foot basis to crops. The indirect costs and direct costs are allocated to the crop on a per unit basis to determine profit per unit produced.

More detail on the FACTS "Greenhouse Plant Cost Estimation Program" can be obtained from the Horticulture Department, Purdue University, West Lafayette, Indiana 47905 by requesting SB233.

Table 5. An example showing unit cost determination

Crop 2 in *Taxus* R C	
Space occupied 500 sq ft of bench	
Overhead 25¢/sq ft of bench	
Depreciation: 5¢/sq ft of bench	
Months occupied 3 months	
Materials cost $300 (cuttings, pots, soil)	
Labor cost $150	
500 sq ft × $ 30 (25¢ overhead + 5¢ depreciation)	= $150
$150 × 3 months	= $450
$450 + $300 (materials)	= $750
$750 + $150 (labor cost)	= $900
	Total Cost
$900 − 18,000 pots = $0 05 (cost to produce one 2 in *Taxus* R C)	

SUMMARY

The principal reason for being in the plant propagation business is to make a satisfactory profit. Knowing cost of production of items produced and sold is the key to identifying profitable products, making production decisions, and implementing cost control measures. A simple cost accounting system allocates direct materials, direct labor, and overhead costs to a product or crop to provide costs using existing propagation business records. Labor time sheets, materials invoices, crop inventory, and space use serve as the basis of the cost allocation system, rent system, and the crop cost records. These crop cost records show cost, revenue, and profit and allow for comparisons of cost-profit per unit. There are great benefits from this system. Yet it is not costly, uses existing information and, most importantly, identifies cost and profit for each crop.

Tuesday Evening, December 9, 1980

The thirtieth annual banquet was held in the Ballroom of the Copley Plaza Hotel, Boston, Massachusetts.

On behalf of the Society, awards were presented to Mr. Gregory Lloyd, Department of Horticulture, University of Wisconsin, Madison, Wisconsin, for the best graduate student award paper and to Dr Brent McCown who was the advisor for the work presented in the paper by Mr. Lloyd.

The award for the best undergraduate paper was presented to Mr. Daniel Berg, Department of Horticulture, University of Illinois, Urbana, IL, and Dr. Martin M. Meyer, Jr. advisor for Mr. Berg's paper

Wayne Lovelace made the following presentation:

AWARD OF MERIT

Presented by Wayne Lovelace

The recipient of this years Propagator's Award of Merit has been a member of this Society for 18 years. Like many of his fellow plant propagators, he is a graduate of the Horticultural School of Hard-knocks. His early intentions were clearly not horticulture because he received formal training in business administration and had a natural ability for electronics. However, his experiences in a nursery and fruit orchard soon convinced him that propagating plants was both a science and a challenge that made him redirect his energies and talents. His success in the propagation of fruit trees convinced the owners that here was a man who possessed a natural ability. It wasn't long before the fruit nursery and orchard business converted to general nursery stock.

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His love for plants and his sound basic understanding of business management made others realize the potentials of this individual. He was soon hired by another well established nursery as their propagator and also became involved in establishing one of the first successful garden centers in a rapidly growing metropolitan area. In this position he was able to apply both his business management skills along with his love for propagating plants. By trial and error and by keeping accurate records of his successes and failures, he discovered long before many a scientist that the rooting response of many plant species was seasonal. It wasn't long before his achievements were noticed by others and in the late 50's he was invited to become a partner in a new nursery. This new enterprise truly brought out the best in him. Not only did he apply his accumulated knowledge on plant propagation, but he also put into practice sound basic management principles that helped to make his nursery a success. Since necessity is the mother of invention, the need for efficient methods and equipment to produce landscape plants by volume brought out his engineering abilites also. His knowledge of electronics also played an important part in his success in rooting plants and in designing special pieces of equipment. His is probably one of the only nurseries in existence that has a home-made burglar alarm that utilizes the delayed fuse principle to protect his propagating and equipment storage area. This warning system will rival that used at the White House. Any would-be intruder is soon made aware that he or she has been seen on the property as evident by ringing horns, bells and bright lights. And if the intruder does not take the hint it is likely the "gendarme" will be there soon.

Our propagator has always been willing to share his experiences and records with others. He has presented papers to this Society and has participated freely in question box discussions. He was also a member of the Board of Directors of I.P.P.S.

Although he is now in the process of retiring, he continues to remain active in this Society and in state nursery and landscape associations. He is a good friend to beginning nurserymen, and a strong supporter of horticultural programs at universities and community colleges. He has always been progressive but firm in his belief that sanitation, and the application of sound basic propagation practices are essential. It is told that he purchased 5 lbs of Terrachlor many years ago because he suspected a disease was responsible for some of his losses. However, he soon discovered, after doing some reading and reasoning that he had created the problem by being too conservative and overly protective. He gave the Terrachlor away when he recently sold his greenhouses.

His philosophy about attending nursery tours is: "Look for

things that you should not do while looking for things that you should try to apply to your own buisness."

I am sure that you will all agree with me that Carl Orndorff deserves to receive this Award.

Thursday Morning, December 11, 1980

The Thursday morning session convened at 8:15 a.m. with John Havis serving as moderator.

Editor's Note William Snyder moderated a group of short presentations on the propagation of certain woody plants The papers by William Flemer, E.A Dixon, Robert C Simpson, Timothy Brotzman, and Edward H Losely were part of that session.

LINDEN PROPAGATION — A REVIEW

WILLIAM FLEMER, III

Princeton Nurseries
P.O. Box 191
Princeton, New Jersey 08540

Because of their tolerance of city conditions, ease of transplanting, reasonably rapid growth, and fragrant flowers, lindens (*Tilia* spp.) continue to be among the most popular shade trees. There is a wealth of published data on linden propagation, so this short paper will be merely a review of the methods used.

SEED PROPAGATION

All *Tilia* species can be propagated from seed, which is the source of understock for budding, but is not usually used for specimen trees because *Tilia* seedlings vary so greatly. *Tilia* seed is usually considered to be "double-dormant", with a combination of a hard seed coat and a dormant embryo requiring cold treatment. The common procedure is to collect seed after it ripens in the fall, mix it with damp sand, put the seed mix in a box and bury it in a stratification bed out-of-doors in the winter. The boxes of seed are dug up the following fall, the seed is sieved out of the sand and sown in beds. The seed is best sown in shallow rows in the beds and covered with sand to aid in seedling emergence. The emerging seedlings are very delicate and subject to sun scald, so lath screens or shade netting over the seed beds greatly improves seedling stands.

An alternative method of seed treatment is to remove the hard pericarp by scarification or sulfuric acid treatment, as soon as the seed is collected in the fall. Then the seeds are sown

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An alternative method of seed treatment is to remove the hard pericarp by scarification or sulfuric acid treatment, as soon as the seed is collected in the fall. Then the seeds are sown

immediately. Good stands of *Tilia cordata, T. platyphyllos,* and *T. tomentosa* are normal, but *T. americana* seed exhibits great variation in germination from year to year, for no very clear reason. When poor stands occur, it pays to dig the one-year seedlings by hand, carefully, leaving most of the bed undisturbed. Often there will be better germination occuring the second spring.

VEGETATIVE PROPAGATION

Very few shade trees vary so greatly in shape, leaf size, and growth rate as do the lindens. It is not unusual to see seedlings of the same age varying from 5 to 6 feet tall to 12 to 14 feet in the same nursery row. Therefore, at a very early date in Europe, and later in the U.S.A., nurserymen began to propagate the best trees vegetatively, thus greatly increasing ther utility and the demand for lindens.

LAYERING

This ancient method is still employed on a small scale in Boskoop, Holland. "Mound layering" is the preferred method, the mother plants being cut back to the crown each year and the bases of the new shoots being covered with a low mound of soil when they are 6 to 10 inches high. The soil is carefully dug away and the rooted shoots are cut off with shears early the next spring before growth starts. The shoots are usually so lightly rooted that they are cut back and bedded for a year to build a sufficiently large enough root system for out-planting in the field. Layering involves too much hand work, especially weeding the layered plants, to be practical on a large scale. It also works best in the cool summers and abundant sub-soil moisture of Boskoop and is much less effective in the hot, dry summer weather so common in the U.S.A

CUTTING PROPAGATION

In general, linden stem cuttings do not root readily in mist beds, and they are very prone to drop their leaves, after which they will not root. *Tilia cordata* clones are the most likely to propagate by stem cuttings but results with these also vary greatly from year to year. Some clones root more readily than others. Best results (but by no means invariably good stands) seem to occur with 6 inch, pencil-size cuttings made in early July, treated with Hormodin No. 2 powders or by IBA quick dip, and stuck in a very porous medium under intermittent mist. Bottom heat seems to increase rooting percentages and speed of rooting. The cuttings are best over-wintered in the rooting flats, under cold but not freezing storage conditions. The cuttings grow slowly after planting, and should be cut back the following winter and

trained to a single stem. Some trees, like *Platanus* species have better root systems if grown from cuttings rather than from seed. Others, such as *Malus* species, *Sophora japonica*, and *Picea pungens* produce very poor, sparse root systems from cuttings. Lindens are quite prone to wind-throw in wet weather when grown from seed or grafted on seedlings, and cutting-grown plants are even more so. It is probable that bedding-out rooted cuttings for one year and then carefully trimming the roots before transplanting them to the field will be a necessary practice.

GRAFTING PROPAGATION

Although lindens can be easily budded, they are very slow and difficult to propagate by bench grafting. Even when the stands are acceptable, the young grafts grow very slowly and take, at best, two years longer to reach saleable size (6 to 8 feet) than do budded trees. Stands are much better if dormant scions are grafted in February or March on seedlings previously established in pots, but the initial growth in the field of such young grafts is slow and, of course, their root system leaves much to be desired. This method does have value for increasing stock of new cultivars because much smaller twigs can be pot grafted than will serve for bud sticks. Linden species, like maples, are very exacting as to which scion-understock combinations will succeed, and which will not. Successful combinations are listed under the next section on budding lindens.

PROPAGATION BY BUDDING

Lindens are among the easier trees to bud successfully and are comparable to apples or pears in bud stands. Unlike red and silver maples or pin oaks, incompatibility is extremely rare if the proper understock-scion combinations are used. If improper combinations are attempted, the bud stands look excellent through the first winter but subsequent growth the first summer after cutting back the understock shows the trouble immediately.

Budding is by the normal process, making a T-shaped incision and dewooding the buds prior to insertion. Best stands occur in the East by budding onto vigorously growing understocks about August 15th. Earlier budding can be unsuccessful on very vigorous understocks because the seedling bark may heal over and bury the bud. Later budding can be a problem because reduced sap flow can make the understocks or bud sticks refuse to peel. If the bud sticks will not peel but the understocks will, "flat" or unpeeled buds are almost as successful as peeled or dewooded buds. Several English growers use chip budding for lindens, but in the U.S.A., stands using this method have never been as good as by "T" budding. The rubbers should be cut 2 or

3 weeks after budding. If they are not cut, they will rapidly be overgrown by the expanding seedling bark and late wind storms will snap off the seedlings. Understocks are normally cut back in January or February and the buds sprout the following late April. Linden seedlings, especially those of *Tilia cordata*, sucker abundantly form the base, and the young budded trees should be suckered several times during the first summer after cutting back. Final bud stands are greatly enhanced by inserting an inexpensive 3 or 4 foot light bamboo cane into the ground beside the understock and tying the scion sprout to it in several places to prevent blow-off in thunderstorm gusts. Also, tying to a stake or using Frank Schmidt's "Grow Straight" irons will produce far superior trees because linden buds tend to grow out horizontally for a few inches before bending up, thus causing an unsightly bow in the trunk.

As noted earlier, scion-rootstock compatibility between linden species is critical. Thus, *Tilia cordata* will grow on *T. cordata* or *T. vulgaris* (*T. x europaea*) understocks and vice versa. *Tilia x euchlora* will grow on *T. cordata*, *T. platyphyllos*, or *T. americana*. *Tilia americana*, *T. platyphyllos*, *T.x euchlora 'Redmont'*, *T. tomentosa*, and *T. petiolaris* will all grow on seedlings of *T americana*, *T. platyphyllos*, and *T. tomentosa*. Curiously enough, although *T. cordata* and *T. platyphyllos* will hybridize (thus producing *T.x vulgaris* or *T. x europaea*), neither will grow on the other as an understock.

PROPAGATION OF CERTAIN *CHAMAECYPARIS* CULTIVARS AND OF *ACER JAPONICUM* 'ACONITIFOLIUM'

E.A. DIXON, JR.

Dixon Tree Farm & Nursery
Glenmoore, Pennsylvania 19343

In general, all Chamaecyparis cuttings were stem cuttings stuck in sand with a bottom heat of 70 to 75°F. Air temperature was maintained generally at 55 to 65°F but reached 80°F on sunny days. Cuttings were kept under intermittent mist 12 seconds every 6 minutes controlled by a photo-electric switch set so that a misting occured only when cuttings were subject to direct sunlight. All cuttings were taken after the first hard frost; that is, in November and December in Pennsylvania.

Chamaecyparis obtusa 'Nana Gracilis'. Cuttings were taken from tips of terminal or lateral stems and were approximately 10 cm long. As this cultivar has a tendency to revert to the species, care must be taken to insure that no cuttings are taken from

3 weeks after budding. If they are not cut, they will rapidly be overgrown by the expanding seedling bark and late wind storms will snap off the seedlings. Understocks are normally cut back in January or February and the buds sprout the following late April. Linden seedlings, especially those of *Tilia cordata*, sucker abundantly form the base, and the young budded trees should be suckered several times during the first summer after cutting back. Final bud stands are greatly enhanced by inserting an inexpensive 3 or 4 foot light bamboo cane into the ground beside the understock and tying the scion sprout to it in several places to prevent blow-off in thunderstorm gusts. Also, tying to a stake or using Frank Schmidt's "Grow Straight" irons will produce far superior trees because linden buds tend to grow out horizontally for a few inches before bending up, thus causing an unsightly bow in the trunk.

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Chamaecyparis obtusa 'Nana Gracilis'. Cuttings were taken from tips of terminal or lateral stems and were approximately 10 cm long. As this cultivar has a tendency to revert to the species, care must be taken to insure that no cuttings are taken from

shoots that are reverting In order to have cuttings of workable size, the basal portion of the cutting includes older growth. A 1-1½ cm wound is made on one side of the cutting, which is then treated with 0.8% IBA talc (Hormodin No. 3).

Chamaecyparis pisifera 'Filifera Aurea' and *C.p.* 'Aurea Nana'. 'Filifera Aurea' and 'Aurea Nana' are treated alike except that cuttings of 'Filifera Aurea' are taken from only those stems which show a definite tendency to grow upwards rather than laterally or down. This procedure is designed to preclude the possiblity that the rooted cutting would grow too wide in proportion to its height. A 1-1½ cm wound is made on one side of the cutting. The cutting is treated with 0.3% IBA in talc (Hormodin No. 2). Cuttings should be sufficiently rooted in 90 to 100 days to be pulled.

Acer japonicum 'Aconitifolium'. This work was based on an article by James Wells on rooting *A. palmatum* (1) on the hypothesis that what worked for *A. palmatum* may very well work for *A. japonicum*. It did. Work was done on both *A. japonicum* 'Aconitifolium' and *A. japonicum* 'Aureum'. While some progress was made rooting 'Aureum', further work must be done.

Stock plants were received and potted up in March and maintained in a heated greenhouse, and drip irrigated with N-K injected into the irrigation system during the growing period. Cuttings were taken the last week in May through the first week in June, from the tips of new growth which were semi-hard: green on one side of the stem and reddish green on the other. In many cases, a second flush of growth had started at the time the cuttings were made. Most cuttings were 6 to 10" long and contained from 1 to 4 nodes. However, having a node in the sand was not necessary for rooting. Larger cuttings tended to root better than the smaller ones. A 2 to 3 cm wound was made on one side and the cutting dipped in a 2% IBA talc powder (HormoRoot 2). All cuttings were stuck in sand under intermittent mist with bottom heat set at 70 to 75°F, although the heat rarely needed to be on. The air temperature was 60 to 90°F, the house being under 55% shade.

Cuttings had ½" or longer roots in 30 to 45 days after sticking at which time they were removed from the sand and potted in rose pots. The pots were then returned to the mist beds until the roots reached the bottom of the pots which took approximately 2 to 3 weeks. At this time the cuttings were removed from the mist, potted up to 1 gallon containers, and fertilized. In addition, one leaf was removed from the bottom node if a leaf was not already missing from the node

After removal from the mist the rooted cuttings were maintained in a greenhouse and placed under incandescent light of

over 200 foot candles from 8:00 p.m. to midnight. For reasons totally unrelated to the experiment, the plants were removed from the supplementary light at the end of July for several weeks. Intermittent supplementary incandescent lighting was then resumed at 200 to 2000 foot candles, for 15 minutes out of every 45 minutes from dusk to dawn. By mid-August there was new growth on most, but not all of the rooted cuttings. Some of the plants continued to grow until the end of November, after which time all growth seemed to stop and gradually the leaves began to assume their fall color, despite the intermittent supplementary lighting. The temperatures in the greenhouse during the fall ranged from 50 to 80°F.

Preliminary indications are that a minimum temperature of 55°F or more, together with supplementary intermittent lighting, is necessary to prevent dormancy. Furthermore, it is questionable whether supplementary lighting is necessary during long periods of daylight in the summer months. Cuttings that did not put on new growth after rooting did not survive the winter.

LITERATURE CITED

1. Wells, James S 1980 How to propagate Japanese maples. *Amer Nurseryman* 151 (9) 14, 117-120

PROPAGATING DECIDUOUS HOLLY

ROBERT C. SIMPSON

Simpson Orchard Company, Inc.
Vincennes, Indiana 47591

Deciduous hollies should be of interest to growers because to date they have been overlooked as a valuable ornamental. The three species most commonly available are *Ilex decidua, I. serrata* and *I. verticillata.* Publications of the Holly Society of America list 25 or more named selections of species or hybrids (Table 1), few of which are commerically available.

Most seedlings are slow to fruit well, approximately half are male and fruitless, and are quite variable. The named selections are vastly superior but few of these are listed in nursery catalogs or garden publications and rarely available. Few ornamental shrubs can surpass these deciduous hollies for effective fruit display. Properly promoted they could fill a need for fall and winter color in the landscape.

I have been interested because this group of plants has such great potential To date little has been done even to propagate

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Table 1. Named selections of deciduous hollies[1]

Ilex decidua		
'Byers' Gold' (Byers) — Registered		
'Council Fire' (Hartline) — Registered		
'Pocahontas' (Hartline)		
'Sundance' (Hartline)		
'Warren's Red' (Warren)		
Ilex serrata		
'Christmas Cheer' (Gulf Stream)		
'Leucocarpa' (white fruit — Hu)	(Dr Shiu-Ying Hu)	
'Xanthocarpa' (yellow fruit — Hu)		
Ilex verticillata		
'Bright Horizon' — Registered	→	Mrs Julian (Polly) Hill
'Earlibright' — Registered	→	Vineyard Haven, Mass 02568
'Cacapon' — Registered	→	O M Neal
'Fairfax' — Registered	→	1248 Oxford Place
'Jackson' (male) — Registered	→	Morgantown, W Va 26505
'Shaver' — Registered	→	
'Red Sprite' — Registered		Louis Sicbaldi
(previously listed as *I*		Hampden Nurseries
macrocarpa or *nana*)		Hampden, Mass 01036
'Christmas Gem' — Origin Unknown		
'Maryland Beauty' — Origin Unknown		
'Xanthocarpa' — Origin Unknown		
'Aurantiaca' (Gulf Stream)		
'Afterglow' (Simpson)		
'Winter Red' — Patent #29912 (Simpson)		
Hybrid (I serrata x I verticillata)		
'Harvest Red' — Registered	→	Elwin R Orton
'Autumn Glow' — Registered	→	Rutgers University
'Raritan Chief' — Registered	→	New Brunswick, N J
'Apollo' (male) — Registered	→	U S National Arboretum
'Sparkleberry' — Registered	→	Washington, D C 2002

[1] Taken from various publications of the Holly Society of American and nursery listings

and distribute the fine selections and hybrids already available. Evaluation of these selected cultivars over a wide area is needed. But first they must be propagated, advertised and made available. The U S. Plant Introduction Station, Glenn Dale, Maryland has distributed initial material to cooperators as has the U.S. National Arboretum, Washington, D.C.. It is up to commercial nurserymen to propagate these from stock plants and offer them to the public. Often the only source of propagation material is in the form of unrooted cuttings from the original plant. Little published information is available on propagation of the deciduous hollies.

MATERIALS AND METHODS

Ilex decidua. Of the three deciduous hollies, *I decidua* is the most difficult to propagate. Individual cultivars vary greatly in this respect. Harline, (6) reports the yellow selection, 'Byers Gold' very difficult to root. For other *I. decidua* selections he has found

fall rooting the most satisfactory method. Cuttings 8 to 10 inches long are taken after the first 2 or 3 frosts, or by mid-October. The leaves are stripped and the cuttings stuck in beds with bottom heat of 72 to 75°F. The medium is peat and perlite. Cuttings are side wounded and treated with Hormodin #3 (0.8% IBA). Beds are in a polyhouse, with an additional plastic cover. Cuttings normally root within 4 to 6 weeks, but root growth is slow. Top growth breaks about the same time. If dormant cuttings are taken, top growth begins before rooting and death results. Plants are maintained in beds until April or May, when they are transferred to one gallon cans for growing on. The container medium is hardwood bark and sand (5:11 v/v). A level teaspoon of Mag-Amp is placed in the root area and a top dressing of Osmocote added.

Because of difficult rooting, Hartline whip grafts 'Byer's Gold' onto established *I. decidua* understocks.

Bill Cunningham, Cunningham Gardens, Waldron, Indiana has rooted *Ilex* cuttings for us for many years. He prefers softwood cuttings under glass, with mist, timed according to weather conditions. Cuttings are taken in early July as growth begins to harden. The proper degree of maturity seems to be critical. Here again success varies with cultivars.

In his procedures cuttings 5 to 6 inches long are treated with 7,500 ppm IBA, quick dip, and stuck in flats containing equal parts peatmoss and polysyrene. Rooting requires 4 to 6 weeks. Plants are then transferred to 2¼" peat pots of standard potting mixture with a pH of 5.6 to 6 and placed in flats. The flats are carried in polyhouses with a combination of mist and fog. They are wintered at 33 to 35°F. New growth breaks about March first. The poly cover is removed in early May but Saran screening of 45 to 50% shade is maintained.

Around June first the first flush of growth begins to harden. At this time we pick up the plants. They are set directly in beds under lath for the remainder of the growing season, with field planting the following spring.

Ilex verticillata and *I. serrata.* Cunningham roots our *I. verticillata* and *I serrata* in the same manner. We supply vigorous growths of up to 24 inches. In most cases more cuttings are returned than shoots sent. These produce plants 10 to 30 inches in height and ¼ to ⅜ inches caliper by fall. Two years in the field give heavy fruiting well branched plants. The cultivar 'Winter Red' has rooted especially well.

The northern type of *I. verticillata* is much more dwarf, compact and has smaller harder leaves than the more vigorous southern type. Cultivars vary in ease of rooting, and subsequent growth is much slower than the southern types.

DISCUSSION

One problem arising with the production of named cultivars is that of appropriate male plants. *Iléx decidua* and *I. opaca* usually over-lap in blooming dates so *I. decidua* will usually set well if male *I. opaca* are near by. *I. serrata* is not usually pollinated by the more common or southern type of *I. verticillata* as blooming periods may not over-lap. The northern type *I. verticillata* may not be pollinated by males of the southern type, due to different blooming periods. However, most selections of the northern type *I. verticillata* and *I. serrata* do bloom together.

For the deciduous hollies to be popular and used over an extended range, consideration must be given to selected male cultivars, appropriate to the fruiting selections. Blooming periods may vary somewhat from year to year, depending upon weather conditions (1). Table 2 illustrates this difference for the year 1979.

CONCLUSION

As named and advertised cultivars become more generally available the demand for and use of deciduous hollies will increase. Where properly used and seen by the public they will be their own best advertisement.

Table 2. *Ilex* blooming dates, Vincennes, Indiana, 1979

I. decidua (early)	May 13-26
I decidua (late)	May 17-30
I opaca, most cultivars	May 19-30
I serrata (well pollinated)	June 5-12
I verticillata (northern type)	
'Aurantiaca'	May 30-June 4
Collected seedlings, (N H)	May 30-June 6
'Afterglow'	June 4-14
'Shaver'	June 6-15
'Cacapon'	June 6-15
'Jackson' (male)	June 6-15
'Fairfax'	June 9-18
I verticillata (southern type)	
Earlier individuals	June 11-29
'Winter Red'	June 12-29
Most seedlings, southern type	June 19-July 3

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5 Dudley, E 1978 Final report on grant for holly hybridization, Sept 1975 — 1978, other significant research noted by research and development committee *Proc Holly Soc Amer* 55 23-24

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7 Eisenbeiss, G K and T R Dudley 1980 International *Ilex* registration *Proc Holly Soc Amer* 57 2

SOME TRIALS IN THE PROPAGATION OF *ACER SPECIES* BY CUTTINGS

TIMOTHY C. BROTZMAN

Brotzman's Nursery
Madison, Ohio 44057

The propagation of certain maples at Brotzman's Nursery began three years ago on a rather limited basis and remains so today. My initial efforts were stimulated by an interest in the genus and a desire to obtain some of the more uncommon and ornamentally desirable species Though by no means complete or absolute, I would like to share with you the results of my experiments.

Propagation facilities. The facility used is a 45 feet polyethylene covered hut with unheated ground beds 8 inches deep, filled with a propagation grade of silica sand. A 62% shade cloth covers the hut at all times. Inside summer temperatures and humidity can get very high, but neither seem to have an adverse effect on rooting.

Propagating procedures. Depending upon species and stage of growth, cuttings are taken from mature to semi-mature trees in late June through late July. Cuttings are of current season's wood, usually 4 to 8 inches long with the basal cut unrelated to node location. The bottom ⅓ to ½ of the leafier stems are stripped of leaves and the remaining leaves of such large leaved species as *A. macrophyllum, A. tegmentosum* and *A. cappadocium* are cropped back 50% Heavy cuttings are given two shallow wounds about 1 inch long, although most require a single wound. Following a 25% Choloromone-in-water quick dip, or an IBA in talc treatment, the cuttings are inserted in either the ground bed or 4-inch deep flats of fine sand and placed under intermittent mist. Once rooted, cuttings are weaned away from the mist to avoid saturation of the root zone.

4 Eisenbeiss, Gene and T R Dudley 1978 International *Illex* registration *Proc Holly Soc Amer* 55 17-18

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Overwintering. During the winters of 1978-79 and 1979-1980, the unheated hut was protected only by an air inflated double polyethylene layer and the shade cloth. Though coldest bed and air temperatures are not known, freezing was not uncommon. Due to unsatisfactory overwintering of some *Acer* species and injury to cuttings of other plants, those in the bed during 1980-1981 will be given the additional protection of polyfoam blanket. Flats will be stored in a covered pit with thermal blankets laying directly over their tops.

Rooting performances. Table 1 indicates my experiences with rooting *Acer* cuttings. Complete data from some trials were not available and, for the 1980 season, rooting percentages were based on the firmness of the cuttings in the medium, not from visual inspection of roots.

Table 1. Rooting results of selected *Acer* species

Plant	Date taken	Quantity	Hormone treatment	Rooting medium	Percent rooted	Over-wintering success
A buergeranum	6/22/80	43	2% IBA	fine sand	60%	
A buergeranum	6/22/80	25	25% Choloro-mone	fine sand	36%	
cappadocicum 'Aureum'	6/22/80	27	2% IBA	fine sand	78%	
A cappadocicum 'Aureum'	6/22/80	19	25% Chloro-mone	fine sand	79%	
A capillipes	7/78	8	2%(?) IBA	silica sand	100%	100%
A capillipes	7/3/80	22	8% IBA	fine sand	68%	
A cissifolium	7/78	?	1%(?) IBA	silica sand	100%*	100%*
A griseum	6/27/79	75	1 5% IBA	fine sand	75%	50%*
A griseum #1	6/25/80	17	2% IBA	fine sand	41%	
A griseum #2	6/25/80	6	2% IBA	fine sand	17%	
A griseum #3	6/25/80	14	2% IBA	fine sand	64%	
A griseum #4	6/25/80	7	2% IBA	fine sand	71%	
A griseum #5	6/25/80	15	2% IBA	fine sand	80%	
A griseum #6	6/25/80	27	2% IBA	fine sand	70%	

Table 1. Rooting results of selected *Acer* species (continued)

Plant	Date taken	Quantity	Hormone treatment	Rooting medium	Percent rooted	Over-wintering success
A griseum	6/25/80	70	2% IBA	fine sand	66%	
A henryi	6/22/80	6	2% IBA	fine sand	100%	
A macrophyllum	6/22/80	?	2% IBA	fine sand	0%	
A macrophyllum	6/22/80	?	25% Chloro-mone	fine sand	0%	
A miyabei	6/22/80	44	2% IBA	fine sand	98%	
A miyabei	6/22/80	40	25% Chloro-mone	fine sand	95%	
A pseudo-sieboldianum	6/22/80	49	2% IBA	fine sand	61%	
A spicatum	7/78	?	2% IBA	silica sand	25%	0%
A spicatum	7/19/79	?	1 5% IBA	silica sand	0%	
(single node)						
A spicatum	7/3/80	24	8% IBA	silica sand	17%	
A tegmentosum	7/79	?	1.5% IBA	silica sand	75%*	100%*
A tegmentosum	7/3/80	183	8% IBA	silica sand	70%	
A triflorum	6/22/80	45	2% IBA	fine sand	58%	
A triflorum	6/22/80	12	25% Chloro-mone	fine sand	17%	

* Exact percentage not known — this is a close estimation

OBSERVATIONS AND CONCLUSIONS

Most rooted cuttings will not break dormancy before autumn leaf drop. However, those that do will overwinter much better than those that do not Perhaps by taking the cuttings earlier the use of supplemental lighting or gibberellic acid would enhance the initation of new growth

Root disturbance, especially in *A griseum*, before dormancy brakes, is disastrous. Delaying transplanting until new growth begins and keeping the roots from freezing should greatly reduce mortality. Direct sticking in pots might be an answer.

My trials included cuttings from 6 *A. griseum* selections and random field assortments. From the results, I conclude that clonal selections for rootability should be made.

Strength of hormone is important for quick, well-structured rooting, and needs to be increased as the season and the hardness of the wood develops. Chloromone, I had been told, works better than powders on green-stemmed cuttings with heavy lenticels. Though used here with no noticable positive results, I will pursue the use of Chloromone again in the future.

In most cases there has been a limited number of cuttings at my disposal, so I have not been able to test the importance of cutting length or number of nodes (usually 3-4) in my trials. One sample of single node *A. spicatum* cuttings, however, did not root at all, whereas multi-node cuttings did. Perhaps the successes enjoyed by many nurserymen with single node cuttings of *A. rubrum* cultivars are not possible with all *Acer* species.

I was very surprised by the good rooting of *A cappadocicum* 'Aureum' despite the fact that the cuttings were stuck fresh, with no special preparations. I though that such species with milky sap did not root easily. In the future, I will try to duplicate this success with *A. campestre, A. mono* and *A plantanoides.*

Cuttings must be weaned away from the mist as soon as they are rooted; good drainage around the new roots is important. In one case a raised flat of *A. griseum* cuttings sitting next to cuttings in the bench rooted much better, indicating the advantage of better medium porosity. I will also try various peat, styrofoam and sand mixtures in an effort to eliminate the excess weight of sand-filled flats

PROPAGATING PIERIS AND LEUCOTHOE

EDWARD LOSELY

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Perry, Ohio 44081

This presentation will restrict itself to those *Pieris* and *Leucothoe* species that are produced at our nursery. We propagate and grow *L. fontanesiana (L. catesbaei);* *L. fontanesiana* 'Girard's Rainbow, a form with mulit-colored leaves; and the related *L. axillaris,* a plant with smaller leaves, smaller stature, and more compact habit of growth. We propagate and grow our own selection of *Pieris japonica* and also *P. japonica* 'Variegata'. We tried and discarded several so-called pink selections of *P. japonica* as not hardy enought for field production in northeast Ohio.

All *Leucothoe* and *Pieris* are propagated from cuttings using a procedure developed by our propagator, John Ravenstein.

Strength of hormone is important for quick, well-structured rooting, and needs to be increased as the season and the hardness of the wood develops. Chloromone, I had been told, works better than powders on green-stemmed cuttings with heavy lenticels. Though used here with no noticable positive results, I will pursue the use of Chloromone again in the future.

In most cases there has been a limited number of cuttings at my disposal, so I have not been able to test the importance of cutting length or number of nodes (usually 3-4) in my trials. One sample of single node *A. spicatum* cuttings, however, did not root at all, whereas multi-node cuttings did. Perhaps the successes enjoyed by many nurserymen with single node cuttings of *A. rubrum* cultivars are not possible with all *Acer* species.

I was very surprised by the good rooting of *A cappadocicum* 'Aureum' despite the fact that the cuttings were stuck fresh, with no special preparations. I though that such species with milky sap did not root easily. In the future, I will try to duplicate this success with *A. campestre, A. mono* and *A plantanoides.*

Cuttings must be weaned away from the mist as soon as they are rooted; good drainage around the new roots is important. In one case a raised flat of *A. griseum* cuttings sitting next to cuttings in the bench rooted much better, indicating the advantage of better medium porosity. I will also try various peat, styrofoam and sand mixtures in an effort to eliminate the excess weight of sand-filled flats

PROPAGATING PIERIS AND LEUCOTHOE

EDWARD LOSELY

Herman Losely & Son Nursery, Inc.
Perry, Ohio 44081

This presentation will restrict itself to those *Pieris* and *Leucothoe* species that are produced at our nursery. We propagate and grow *L. fontanesiana (L. catesbaei);* *L. fontanesiana* 'Girard's Rainbow, a form with mulit-colored leaves; and the related *L. axillaris,* a plant with smaller leaves, smaller stature, and more compact habit of growth. We propagate and grow our own selection of *Pieris japonica* and also *P. japonica* 'Variegata'. We tried and discarded several so-called pink selections of *P. japonica* as not hardy enought for field production in northeast Ohio.

All *Leucothoe* and *Pieris* are propagated from cuttings using a procedure developed by our propagator, John Ravenstein.

Cuttings are made in mid-October. To facilitate the taking of cuttings we usually dig up several plants from our field production. We find it more efficient to remove the cuttings at a work bench than bending down in the field. A further advantage of digging the stock plants is that, when necessary, the cutting material is more easily stored than severed cuttings; i.e., only the roots need to be kept moist.

The cuttings are cut to length as they are removed from the stock plants. They are then immersed in a tub of well water and agitated by hand to remove adhered soil, particulates, and to reduce any pesticides that may be present. The *Leucothoe* cuttings are 4 to 5 inches long and the *Pieris* cuttings are approximately 2½ inches long. Terminals are left on all the cuttings. Leaves are stripped from approximately one inch of the basal end; this is usually about two nodes. After stripping, the cuttings are placed in flats with the basal ends up. This procedure is followed to permit the basal ends to dry prior to dipping in Hormodin No. 2. We feel that too much hormone powder may adhere to the wet cuttings. The cuttings are inserted into 3 inch deep white cedar flats that are filled with a medium composed of Canadian spagnum peat moss (Heveco Brand), coarse horticultural perlite, fine horticultural perlite, mason grade silica sand (5:2:2:1 V/V). The flats are placed on benches and watered thoroughly. Bottom heat is maintained at 65 to 70°F. Syringing is accomplished by a mist line that is operated manually at this time of the year, since we experience much cloudy weather. An occasional hose syringing is done to maintain an optimum moisture level in the medium. A weekly dusting with Captan dust (7½%) is applied to the foliage. When the outside temperature permits, we find that by running the exhaust fans at one end of the propagating house while operating a hand cranked duster at the intake end of the house, the Captan is applied with a minimum of time and effort.

The cuttings develop root balls approximately the size of a quarter in 6 to 8 weeks. They are then transplanted 28 plants per flat into white cedar flats measuring 22 × 15½ × 3 inches deep. The medium is a coarse horticultural grade Michigan sedge peat. The flats of transplants are placed on benches in double layered, air inflated, clear poly houses that are maintained at 50°F.

As the days lengthen and light intensity increases in mid to late February, the plants break dormancy and are lightly top-dressed with a slow release fertilizer (Scotts Pro Grow 24-9-9). The plants are pruned one or two times by cutting off the tops with a hedge shear.

By early to mid-June they have grown to be 4 to 6 inch plants with good root systems and are ready for planting into outdoor ground beds.

TOM McCLOUD: Question for Bob Simpson. Are there any selections of *Ilex* males that are more preferable?

ROBERT SIMPSON: Yes. The cultivar 'Winter Red' blooms earlier than the majority of the seedlings we have. So we have selected some earlier blooming male forms to go with that cultivar. *Ilex veritcillata* 'Aurantiaca' also flowers very early.

FRANK GUOIN: Question for Bill Flemer. At the Toronto meeting a paper was presented on harvesting *Tilia* seed when nearly all the seed coats had turned from green to grayish brown. Have you tried that?

BILL FLEMER: We have tried it but it has been inconclusive for us. Some times we harvest then on the gray side and they turn to mush for us. We have not been able to pinpoint the exact time. I suspect it varies from year to year. We have settled on picking the seed when we know they are ripe and going through the traditional method

DICK JAYNES: Question for Bob Simpson. What is the possibility of selecting a monecious clone?

BOB SIMPSON: There are no clones that contain both male and female flowers. I have seen male hollies with fruit but that was from some type of shock.

RALPH SHUGERT: Comment to Bill Flemer. My experience with *Tilia* × *euchlora* 'Redmond' is that it is equally compatible with *T. americana* and *T. cordata*

BILL FLEMER: It seems to grow faster on *T. americana* and appears to be more dwarf on *T. cordata* with us. There is a question in my mind if it is a *T.* × *euchlora*. I have sent specimens to various arboreta asking what it is and it comes back as *T. americana*. It may therefore not be *T.* × *euchlora*.

VOICE: Question for Timothy Brotzman. How old were the maple trees you were taking cuttings from?

TIMOTHY BROTZMAN: They were quite variable in age. For example, the *Acer henryi* was 4-5 years while *A. miyabei* was probably 25 years old The *A. griseum* was about 8 years old.

PROPAGATION OF THORNLESS-FRUITLESS SELECTIONS OF OSAGE ORANGE[1]

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ABSTRACT. Several clones of Osage orange were propagated using T-budding, softwood and hardwood cuttings from mature and from juvenile portions of male, thornless trees Most clones produced thorny juvenile growth especially when budded hardwood cuttings rooted 100% at 5,000 ppm IBA and produced thornless plants at moderate fertility levels

REVIEW OF LITERATURE

Osage orange, *Maclura pomifera* (Raf.) Schneid., is used primarily for hedges and windbreaks in the plains states, hence the name "hedge tree" is commonly applied (5). The tree has also been advocated for planting as an ornamental in difficult sites (3) and more recently as a possible urban tree, because it tolerates considerable pollution (1). The objectionable thorns and baseball-size fruit on female trees can be overcome by selecting and propagating superior male clones.

Although Rehder (4) lists a thornless variety, *M. pomifera var. inermis*, it is seldom found in nature and few have been commercially propagated. Old, "thornless" trees often produce thorns on vigorous, juvenile growth, although the trait disappears with maturity.

The general phenomenon of juvenility is well known and respected by propagators and is important in maintaining an easy-to-root, juvenile source of cuttings, or conversely, producing more mature wood for early flowering and fruiting. The changes in growth phases and their relation to vegetative propagation have been discussed by Stoutemyer (6).

The term topophysis applies to different parts of the same tree perpetuating particular growth phases (juvenile or mature) during propagation (2). Buds taken from lower, juvenile portions of such species as pear, citrus, or honeylocust often produce nursery trees that are vigorous, thorny, and slow to flower. Buds from the upper, more mature portion of the same tree produce thornless trees that flower more quickly.

In the past several years a search has been underway in several states to find a thornless Osage orange that can be easily propagated. Numerous clones have been evaluated at Kansas

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[2] Research Horticulturist, Wichita Horticulture Research Center and Professor of Horticulture, Kansas State University, respectively

State University including 2 Kansas cultivars 'Pawhuska' and 'Chetopa', named for Osage Indian chiefs, that were released by the Kansas Agriculture Experiment Station in 1974. A third selection, 'Park', is being grown by Willis Nursery, Ottawa, Kansas. Others grown by Texas nurseries are 'Fan d'Arc' and 'Bois d'Arc Supreme' The name Bois d'Arc refers to the Indians' use of its wood for bows Clones being evaluated from Iowa include 'Osage Chief', 'Keokuk', and 'Solomon', and a tree recently discovered near Wichita (referred to by that name) appears promising in preliminary tests.

MATERIALS AND METHODS

Objectives of this experiment were to determine the effects that various propagation techniques and nursery practices have on growth and thornlessness Compared were (1) T-budding, (2) softwood cuttings, and (3) hardwood cuttings, taken from mature and juvenile portions of mature trees.

Budding. Seed for producing understock were removed by soaking the large leathery fruit until fermentation allowed the seed to slip freely from the "mash". Seeds were then sown either in a cold frame or directly in a nursery row where budding was to be done

Fall sowing, to insure stratification, produced thorny seedlings large enough to bud by August or the following May. One year-old understock was lined out in the spring and budded as soon as the combium became active. Some T-budding was done in May but the best trees were produced from August buds froced the following spring.

Rooted Cuttings. Seedling understock could potentially produce thorny root sprouts, although this has not been observed to be a problem Nevertheless, a plant on its own roots avoids this and other incompatibility problems resulting from a graft union.

Softwood cuttings of 3 selections were compared for rootability and for growth and thornlessness when grown in a field soil or in containers. Cuttings taken June 13, 1979, and treated with Rootone F were placed in a sand medium with intermittent mist 10 seconds ever 6 minutes. After rooting, cuttings were potted in 4-inch pots, overwintered under a microfoam blanket, then lined out in a nursery row or potted in 1 gallon containers the next spring.

Hardwood cuttings were examined as a method of producing larger trees in a single season that could be overwintered more successfully than trees grown from softwood cuttings and potted late in the summer. Using dormant cuttings also eliminated the need for an intermittent mist system.

Two thornless male clones were chosen as a source of cut-

tings. Clone 1, discovered near Wichita, had been propagated previously by T-budding and thus provided a source of juvenile wood. Mature wood was also taken from upper protions of the parent tree. Cuttings were taken from both upper and lower portions of clone 2 from the Chisholm farm.

Cuttings were taken January 18, 1980, given a 5 second dip in IBA at concentrations of 0, 1,000, 5,000 and 10,000 ppm and placed in a medium of coarse perlite and sphagnum peat (70:30) over bottom heat. Temperature of the medium was maintained at 65-70°F. An opaque poly tent of milky plastic covered the propagation bed to maintain high humidity until it was removed when more light was needed for shoot development.

After rooting, cuttings were potted in 2¼ inch pots in early March, placed in an outdoor hotbed, and later shifted to 1-gallon containers using a medium of pine bark:peat:sand: (2:1:1) amended with Osmocote formulation 18-6-12 plus 2.5 lbs 0-20-0 superphosphate, 1 lb fritted trace elements and 10 lbs dolomitic lime per yd^3. Pots were treated with an additional ½ or 1 tbsp of surface-applied Osmocote, 18-6-12, on June 23, 1980. Growth and thornlessness were recorded at the end of the growing season.

RESULTS

Softwood cuttings, taken in June, rooted as high as 86% in 5 weeks, but at a lower percentage when cuttings taken in July, although the species can be rooted most months of the year.

Trees grown in the rich but unfertilized nursery soil grew best, but also produced more thorns (Table 1). This indicates the species is better suited to field production than containers. One-gallon containers, even with additional fertility supplied, restricted this vigorous tree species The number of thorns increased with the fertility level which favored vigorous, juvenile growth. Some plants grown at lower fertility levels were completely thornless.

Hardwood cuttings rooted nearly 100% at every level of IBA. Maximum rooting occurred at 5,000 ppm but distribution of rootings improved at 10,000 ppm (Table 2).

Cuttings from both upper and lower portions of clone 2 produced extremely thorny growth the first year. Trees grown from mature wood taken from the upper portion of the tree produced slightly fewer thorns (Table 3). Clone 1 proved quite thornless, and further testing is underway to compare it with others now being grown commercially. Only an occasional thorn could be found even under the highest fertility level tested. Vigorous whips 6 feet tall were also produced without thorns by budding on 2 year understock.

Table 1. Growth and thornlessness of Osage orange selections grown from softwood cuttings [1]

Osage orange selection	Treatment[2]	Season's growth (in)	No thorns per plant
'Park'	1 gal — no additional N	23	5
	1 gal + 5 gms 18-6-12	29	7
	Nursery — no additional N	44	37
'Pawhuska'	1 gal — no additional N	30	4
	1 gal + 5 gms 18-6-12	26	9
	Nursery — no additional N	34	27
Clone No 2 (Chisholm)	1 gal — no additional N	30	15
	1 gal + 5 gms 18-6-12	27	17
	Nursery — no additional N	39	35

[1] Stuck 6/13/79, potted in 4" pots and shifted to 1 gal containers or lined out in nursery on 5/25/80

[2] Soil peat perlite (2 1 1) medium was amended with Osmocote 18-6-12 at 7½ lbs per yd[3]

[3] Half the containers recieved ½ tbsp additional surface-applied fertilizer after potting

Table 2. Effects of IBA concentrations on rooting hardwood cuttings of two Osage orange clones

Clone	Location of cutting[1]	IBA conc (ppm)	Percent rooted
Clone No 1 (Wichita)	High (parent tree)	0	56
		1,000	100
		5,000	100
		10,000	88
	Juvenile (Budded trees)	0	29
		1,000	71
		5,000	100
		10,000	100
Clone No 2 (Chisholm)	High	0	11
		1,000	55
		5,000	100
		10,000	89
	Low	0	0
		1,000	75
		5,000	100
		10,000	100

[1] For comparison of juvenile and mature wood, cuttings were taken from high or low on parent tree or from young vigorous trees in a nursery row

DISCUSSION

Osage orange can be rooted nearly any time of the year, although softwood cutings at the peak of juvenile growth, or hardwood cuttings in mid-winter rooted best. Hormone treatments greatly increased rooting percentages.

Growth in a rich, moist field soil was better than that in the containers although the number of thorns increased with vigor.

Thornless trees produced by T-budding provided a more acceptable nursery tree in one season.

Most so called "thornless" hedge trees may occasionally produce a few thorns on juvenile wood, but this trait can be overcome in time as wood gradually matures so the few thorns should not limit the use of this rugged species in areas nearly impossible for other species to succeed.

Through proper selection, propagation techniques, and moderate fertility levels, it is possible to produce thornless trees acceptable to the nursery trade. Osage orange is easy to propagate in a variety of ways and offers great potential as a tree for difficult sites.

Perhaps it is time to make increased use of this tough, insect and disease resistant species in pollution-clouded inner cities as well as on wind swept prairies and other places where few other tree species could survive.

Table 3. Growth and thornlessness of Osage orange clones as affected by location of cuttings and fertilizer treatments

Clone	Location of cutting[1]	Fertilizer treatment gms[2]	Season's growth (in)	No thorns per tree
Clone No 1 (Wichita)	High (Parent tree)	0	20 3	0
		5	19 2	1
		10	24 6	2
	Nursery trees (Juvenile)	0	8 8	0
		5	16.5	1
		10	15 3	4
Clone No 2 (Chisholm)	High (Parent tree)	0	16 9	18
		5	20 1	14
		10	18 1	18
	Low (Parent tree)	0	20 6	20
		5	21 0	20

[1] Only a small amount of cutting wood was suitable in the lower portions of both trees so young nursery trees were used as a juvenile wood source of the Wichita clone

[2] Original medium contained Osmocote 18-6-12 at 7½ lbs per yd³ Additional, surface-applied treatments of 0, ½, and 1 tbsp per gal container were made June 23, 1980

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BREEDING AND SELECTING CLONES OF RHODODENDRONS INCLUDING AZALEAS

PETER E. GIRARD, SR.

Girard Nurseries
Geneva, Ohio

(See-Proc. Inter. Plant Prop. Soc. 29:431-436 1979).

Thursday Afternoon, December 11, 1980

The Thursday afternoon session convened at 2:15 p.m. with James Sabo serving as moderator.

MYCORRHIZAE AND THEIR USES IN THE NURSERY

STEPHEN D. VERKADE AND DAVID F. HAMILTON

Department of Horticulture
Purdue University
West Lafayette, Indiana 47907

Symbiotic associations between certain soil fungi and plant roots constitute relationships termed "mycorrhizae". Mycorrhizal roots are observed in nearly all native stands of plants, in all parts of the world (4, 14). In climates ranging from tropical to arctic, woody and herbaceous plants are normally involved in this form of symbiosis. Fungal symbionts in mycorrhizal associations include members of the *Endogone, Ascomycetes and Basidiomycetes* (4, 13).

There are two major types of mycorrhizae, distinguished by the way in which the fungus attaches itself to the root (4, 6, 10). The first classification is the ectomycorrhizal group, and the second is the endomycorrhizal group. In ectomycorrhizal associations, a fungal sheath forms around the exterior of the root and is a distinctive visible feature (10). The fungal sheath consists of divided fungal hyphae, but appears superficially as though it were made of plant cells (6). From this outer sheath, hyphae extend outward into the soil, and also inward around the outer cortical cells of the root. The inward extension is termed a *Hartig*

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Net and provides intimate contact for exchange between the two symbionts (6, 10,13).

The second type of mycorrhizae, the endomycorrhizal group, does not have any outwardly visible distinctions, as there is no fungal sheath (4, 6). In this case, however, the hyphae present inside the mycorrhizal root do penetrate the epidermal and cortical cells. The hyphae do not invade the endodermis, stele, or root meristem. Upon infection, the fungi produce structures called arbuscles, which are clusters of fine hyphae, within the cortical cells of the root. As the arbuscles form, starch disappears and the nuclei enlarge within the cell. At some point after this, these formations are digested and the contents absorbed by the plant cell. The nuclei return to the normal size. The formation and dissolution of these structures may serve as the prime mode of exchange between the two symbionts. Endomycorrhizae also contain structures called vesicles, which are ovate to spherical formations containing oil droplets (4). These may remain thin-walled and serve as storage, or become thick-walled and serve as resting spores.

An additional type of mycorrhizae is the ectendo-type, which is an intermediate classification for associations showing characteristics of both ectomycorrhizae and endomycorrhizae (5). Each type of mycorrhizal fungi colonizes the root prior to secondary growth. Upon colonization, the rate of root growth is reduced, and root longevity is extended (4). The results of these interactions are visible and significant increases in overall plant growth.

For woody ornamental species, the endomycorrhizal group has been most studied and is perhaps the most important classification. Although research with endomycorrhizal associations of *woody ornamentals will require expanded effort to thoroughly* explore the subject, increases in height, weight, and survival percentage have been observed for several woody crops (1,7,8,9,11).

Promotions of plant growth by mycorrhizal associations is a well established concept (2,4). These promotions of plant vigor may be mediated by three activites of the fungal symbiont. First, the fungi contribute to plant health through competitive exclusion by lowering root susceptibility to pathogen invasion (2). Colonization by pathogenic fungi, bacteria and nematodes may be reduced by a competition for plant metabolites and exudates, and by way of physical competition by the mycorrhizal hyphae

Secondly, uptake of water may be enhanced in mycorrhizal plants (4). Due to the absorptive surface added by the fungal hyphae and perhaps to more efficient absorption, mycorrhizal plants are observed to have an advantage under moisture stress conditions.

Finally, in a manner similar to moisture uptake, nutrient uptake may also be enhanced (2,4). Increases in absorption of nitrogen, phosphorus, and potassium have been found. The increases in dry weight of mycorrhizal over non-mycorrhizal plants correspond to increases in uptake of N, P, and K. These increases in growth are maximum when comparisons of growth are under conditions of low soil phosphorus (3,4). Thus, it is likely that this component may be more important than other nutrients when considering mycorrhizal interactions. Again, it is believed to be due to the added surface area and perhaps to more efficient uptake by the fungi.

Fungal development and health is also promoted by the mycorrhizal association. The benefits to the fungi begin with the plant exudates from the root (4). The exudates of metabolites, including carbohydrates, are important in mycelial growth and may also function in the initial attraction between the plant root and fungi. The main benefit for the fungi is the use of the root as a carbohydrate source (4).

Research is currently underway at Purdue University, examining the effect of mycorrhizal inoculation on selected woody plant species used in commercial nursery production. The following studies were initiated to investigate some parameters such as spore viability, soil fertility, and temperature which may be useful in evaluating the potential role of mycorrhizal inoculation in the soil management techniques of woody ornamental production.

MATERIALS AND METHODS

The objective of the first experiment was to determine the effects of pasteurized inoculum, containing mostly non-viable spores, on growth of tulip tree, *Liriodendron tulipifera L.* Seedlings were transplanted into 0.98 liter pots (one quart trade designation) containing steam pasteurized medium (2 perlite: 2 peat: 1 soil), fertilized with Osmocote 19-6-12 at a rate of 2 g N/liter. Plants were inoculated with 44,400 spores of *Glomus fasciculatus* (Thaxter) Gerdemann & Trappe per square meter of surface area of the container. In addition to fungal spores and hyphae, the inoculum also contained plant roots and soil. Plants were grown in the greenhouse for 12 weeks and then harvested. Analyses included measurement of height increase, dry weight of shoots and roots, and observation of mycorrhizal infection. Root staining to determine mycorrhizal infection was accomplished by the techniques of Phillips and Hayman (12).

The second experiment examined the effect of inoculation with *G. fasciculatus*, at a rate of 44,400 spores per square meter of container surface area, on tulip trees grown under 3 nutrient

regimes (0, 2, and 4 g N/liter). The experimental plants were grown from seed and transplanted into 3.28 liter pots (one gallon trade designation) containing steam pasteurized medium (2 perlite: 2 peat: 1 soil). Both inoculated and non-inoculated plants were grown under 3 fertility levels supplied by Osmocote 19-6-12 slow release fertilizer, and grown under greenhouse conditions. Analysis of variance was conducted for height increases, dry weight of shoots, and dry weight of roots. Mycorrhizal infection was observed through the use of root stains (12).

The third experiment evaluated the effect of two temperature regimes (40°C day/35°C night and 30°C day/25°C night) on growth of perennial ryegrass, *Lolium perenne* L. Treatments included inoculation with *G. fasciculatus* at rates of 0 or 44,400 spores per square meter of container surface area. Plants were seeded in 0.98 liter pots containing steam-pasteurized medium (2 perlite: 2 peat: 1 soil), and fertilized with Osmocote 19-6-12 slow release fertilizer at a rate of 2 grams N/liter. Plants were grown in a growth chamber at the appropriate temperatures. Analyses included dry weights of shoots, and root staining for observation of mycorrhizal infection (12).

Finally, the effects of incorporation of spores of *G mosseae* into a rooting medium were examined. Cuttings of Regel privet [*Ligustrum obtusifolium var. regelianum* (Koehne) Rehd.] were 16.3 cm long with 8 leaves. The cuttings were stuck either in vermiculite and perlite (1:1) or in the same medium amended with inoculum (3 media:1 inoculum, with 40,800 spores added to a flat 35 × 42.5 × 12.5 cm) or inoculum from the same source but steam pasteurized. The experiment was initiated on September 21, 1980 with cuttings under intermittent mist in a greenhouse with approximately 25% shade. Analyses included fresh weights of roots and enumeration of root initials visibly penetrating the stems of the cuttings. Root staining was conducted for observation of mycorrhizal development (12). Analyses took place on the third and sixth weeks after sticking of cuttings.

RESULTS

Tulip trees, inoculated with steam-pasteurized *G. fasciculatus*, showed minimal mycorrhizal development (less than 2% of cortical cells affected). Upon analysis, the plants inoculated with steam-pasteurized *G. fasciculatus* were not significantly taller and showed no significant increase in mean dry weight of roots or shoots over control plants receiving no treatment (Table 1).

In the fertility study, all non-inoculated plants showed minimal mycorrhizal development, as did inoculated plants grown under unfertilized conditions (0 g N/l). Roots of inoculated plants growing under medium and high fertility levels (2 and 4g N/l)

Table 1. Effect of pasteurized *G fasciculatus* inoculum on height increase, dry weight of shoots, and dry weight of roots of tulip trees

Measurement	Pasteurized inoculum	Control
Height increase (cm)	1 730	1.590
Shoot dry weight (g)	0.708	0.834
Root dry weight (g)	0 750	0.968

were highly mycorrhizal (greater than 50% of cortical cells affected).

At the lowest fertility level (0 g N/l) there was no significant difference in the increase in height of inoculated and non-inoculated plants. At the middle rate (2 g N/l) and high rate (4 g N/l), inoculated plants had significantly greater increases in height than non-inoculated plants. However, there was no real difference between plants receiving the same inoculation treatment in the middle fertility rate (2 g N/l) and the high rate 4 g N/l) (Table 2).

Table 2. Effect of inoculation with *G fasciculatus* on increase in height (cm) of tulip trees grown under three nutrient regimes (0 g N/l, 2 g N/l, and 4 g N/l of Osmocote 19-6-12)

Fertility (g N/l)	Inoculated	Non-inoculated
0	0 84	0.79
2	36.85	13.39
4	40 66	16 42

For dry weight of shoots, there was no difference between inoculated and non-inoculated plants at the 0 g N/l fertility rate (Table 3). At the 2 g N/l rate, shoots of inoculated plants had significantly greater dry weight than those of non-inoculated plants. Dry weights of shoots of inoculated plants grown in soil fertilized at the 4 g N/l rate again were significantly greater than the shoot dry weights of non-inoculated plants. The shoot dry weights of inoculated plants at the 4 g N/l rate were significantly greater than those of inoculated plants at the 2 g N/l rate. However, there was no similar difference between non-inoculated plants at those fertility levels.

Table 3. Effect of inoculation with *G fasciculatus* on shoot dry weights (g) of tulip trees grown under three nutrient regimes (0 g N/l, 2 g N/l, and 4 g N/l of Osmocote 19-6-12)

Fertility (g N/l)	Inoculated	Non-inoculated
0	0 178	0.147
2	7 067	0.671
4	9 406	1 797

For dry weight of roots of plants grown at the 0 g N/l fertility level, there was no real difference between inoculated plants and non-inoculated plants (Table 4). At the 2 and 4 g N/l levels of fertilization, the root dry weights of inoculated plants were significantly greater than those of non-inoculated plants. However, no distinction can be made between the results for the two fertility levels (2 and 4 g N/l).

Table 4. Effect of inoculation with *G fasciculatus* on root dry weights (g) of tulip trees grown under three nutrient regimes (0 g N/l, 2 g N/l, and 4 g N/l of Osmocote 19-6-12).

Fertility (g N/l)	Inoculated	Non-inoculated
0	0.163	0.207
2	2 481	0 481
4	3 100	0 813

The root stains of the temperature project show that there was a small amount (less than 10% cortical cells affected) of mycorrhizal development on inoculated perennial ryegrass plants at the lower temperature studied (30°C day/25°C night). Inoculated plants grown at the higher temperature regime (40°C day/25°C night) exhibited a very small degree of mycorrhizal development, which was less than that developed at the lower temperature regime No mycorrhizal development was noted on the non-inoculated plants.

For the 30°C/25°C treatment, no real difference in dry weights of shoots was detected (Table 5). However, at the higher temperature, the shoot dry weights of the inoculated plants were significantly less than those of the non-inoculated plants.

Table 5. Effect of inoculation with *G mosseae* on dry weight of shoots (g) of perennial ryegrass, grown under two temperature regimes (30°C day/25°C night and 40°C day/35°C night)

Temperature	Inoculated	Non-inoculated
30°C/25°C	2.150	2 210
40°C/35°C	0.120	0 230

From the experiment on the effect of mycorrhizal inoculum on the rooting of Regel privet cuttings, at week 3 after initial propagation, no difference was found among any of the 3 treatments (inoculum amendment, pasteurized inoculum amendment, and control) for number of roots or fresh weight of roots (Table 6 and Figure 1). By the 6th week after initial propagation, the cuttings rooted in media amended with inoculum were highly mycorrhizal, those in media with pasteurized inoculum showed a smaller amount of mycorrhizal development, and those in media with no amendment exhibited virtually no mycorrhizal development.

Table 6. Effect of incorporation of viable *Glomus mosseae* spores and pasteurized spores, into a rooting media, on number and fresh weight of roots of Regel's privet cuttings, as measured on week three after sticking of cuttings

Treatment	Number of roots	Fresh weight of roots (g)
Control	3 00	0 01
Inoculum	0 05	0 00
Pasteurized inoculum	0 00	0 00

On the 6th week, there was no real difference in number of roots found, but there was a separation based on the fresh weights of roots from the 3 treatments (Table 7). The fresh weights of roots from cuttings rooted in media amended with inoculum were significantly greater than those from cuttings rooted in the media with no amendment. The fresh weights of roots from cuttings rooted in the media amended with pasteurized inoculum were not significantly different from either of the other two treatments (Figure 2).

Table 7. Effect of incorporation of viable *G mosseae* spores and pasteurized *G mosseae* spores, into a rooting medium, on number and fresh weight of roots of Regel privet cuttings as measured on week six after sticking of cuttings

Treatment	Number of roots	Fresh weight of roots (g)
Control	4 75	0 21
Inoculum	8 75	0 49
Pasteurized inoculum	6 63	0 34

CONCLUSIONS

From these studies, conclusions relating to the production of woody ornamentals can be drawn. As demonstrated in the experiment on the effect of pasteurized inoculum on growth of tulip tree seedlings, spores and hyphae in the inoculum must not only be present, but also viable if growth increases are to be obtained. Also, inoculation results in important increases in plant growth both at medium (2 g N/l) and high (4 g N/l) fertility levels as shown in the tulip tree study. The shoot: root ratio differs for the 2 treatments, as indicated by the significant increase in dry weights of shoots of inoculated plants at the 4 g N/l level over the 2 g N/l level but lack of a similar increase for the dry weights of roots. More research is needed to determine which fertility level would be superior for establishment and subsequent growth of the mycorrhizal plants.

Not all plants are highly compatible with all species of mycorrhizal fungi. While perennial ryegrass plants grown under

a 30°C/25°C temperature regime did exhibit limited mycorrhizal development, inoculation did not contribute to growth of the plants. In fact, at the higher temperatures (40°C/35°C) growth was actually inhibited, perhaps due to the pathogens which are also introduced with the inoculum. It is important to have a strong plant-fungi compatibility prior to commercial inoculation in a production system.

From this research, no evidence was found to link inoculation with mycorrhizal fungi to promotion of root initiation. Inoculation was shown to result in early development of mycorrhizal roots and increased fresh weight of roots on cuttings of Regel privet. Root fresh weights of cuttings growing in media amended with pasteurized inoculum were intermediate between those growing in media amended with inoculum and those growing in the control medium because of 2 factors. First, the physical role of the amendment (addition of soil, peat, and perlite) may result in an improved rooting media. Secondly, some mycorrhizal development was noted on roots from cuttings rooted in the media amended with pasteurized inoculum, indicating that some spores did survive the steam heat treatment and may have increased root development upon infection. Inoculation in the propagation stage may prove to be most efficient, since it promotes the earliest development of mycorrhizal roots and the subsequent promotions of growth.

Although many woody plants still have not been studied, the concept of growth increases due to the formation of mycorrhizal fungi is well established Evaluation of mycorrhizal inoculation must be considered on a practical and economical basis before the controlled use of mycorrhizal fungi can become a reality for próduction of woody ornamentals. Natural mycorrhizal development is observed under normal production situations, and this factor must be considered when investigating the economical importance of an inoculation program If plants growing in the various media currently in use become inoculated by natural contamination (from the medium, air, and water) in the early stages of plant production, then it may not be necessary or perhaps economically feasible to provide additional inoculation.

While there is little information available on the economical feasibility of inoculation with mycorrhizal fungi in the production of woody ornamentals, certain situations seem to be most suited for inoculation. Such situations may include container production where no soil is included in the growing media; cases where the soil is thoroughly sterilized, as with methyl bromide; and in cases where plants are destined for very harsh growing environments, such as strip mine sites or new highway construction sites.

Recent trends in the production of woody ornamentals have been toward more complete control of the plant environment,

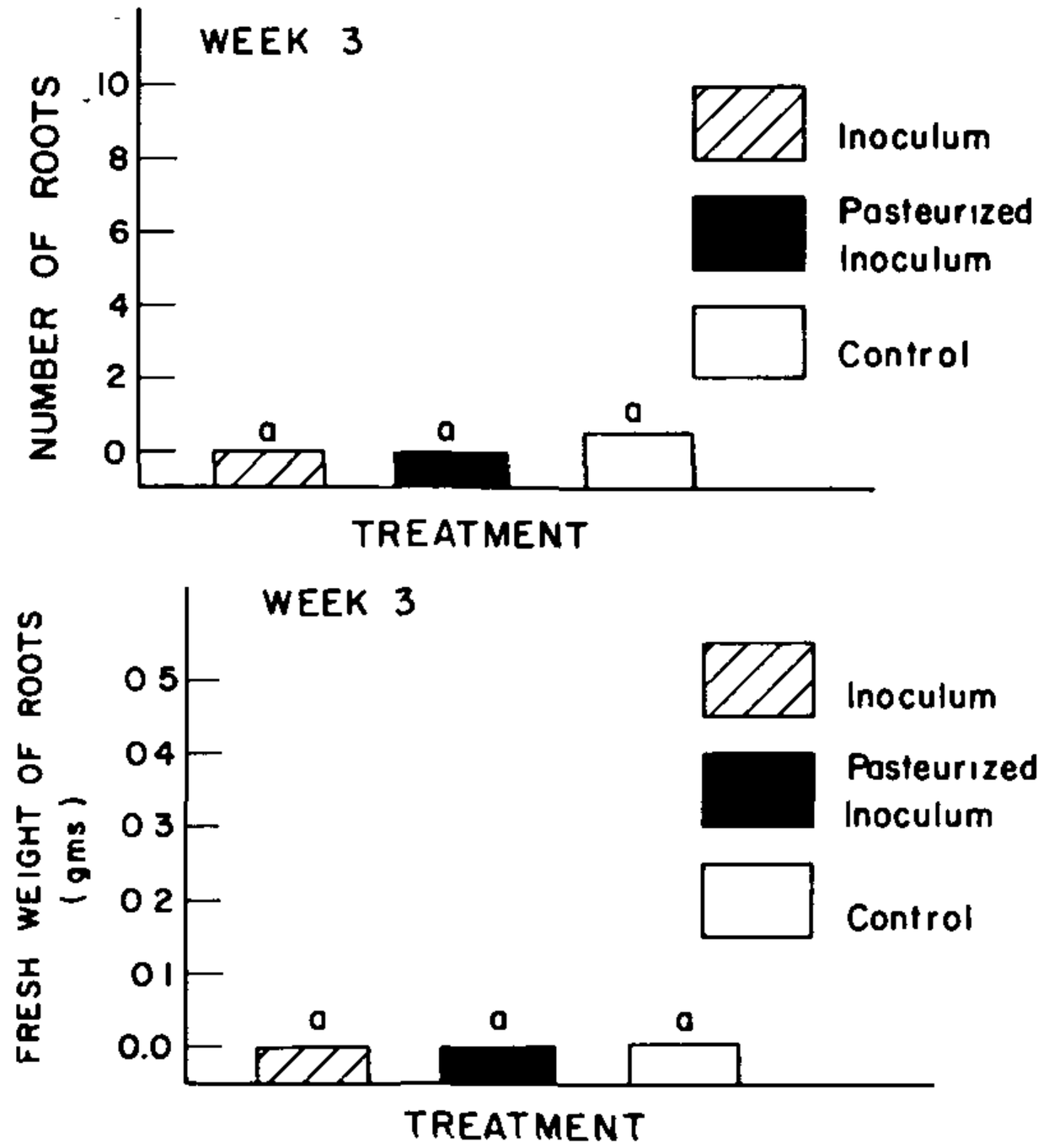

Figure 1. Effect of incorporation of viable *G mosseae* spores and pasteurized *G mosseae* spores, into a rooting medium, on number and fresh weight (g) of Regel privet cuttings as measured on week 3 after sticking of cuttings

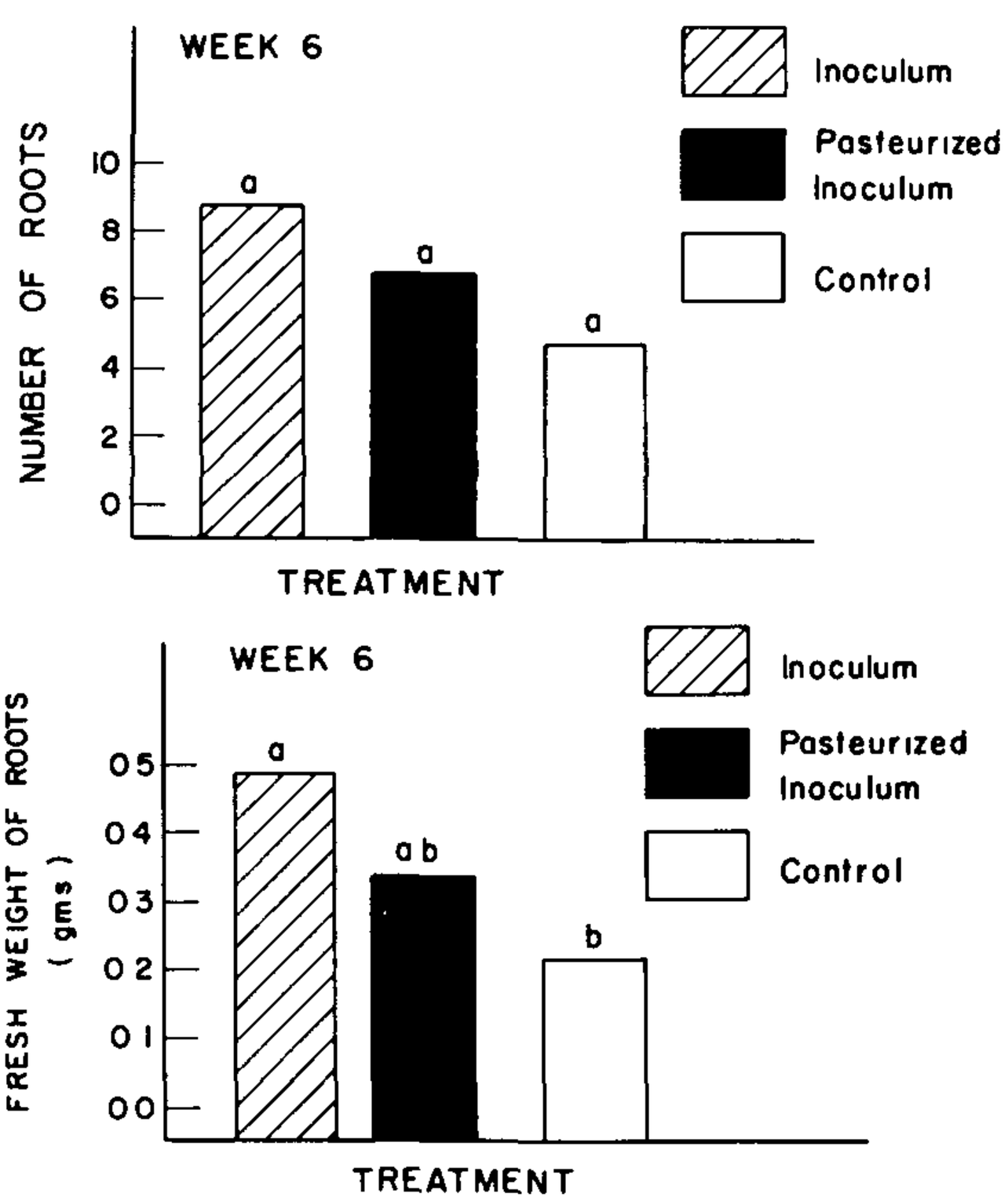

Figure 2. Effect of incorporation of viable *G mosseae* spores and pasteurized *G mosseae* spores, into a rooting medium, on number and fresh weight (g) of Regel privet cuttings as measured on week 6 after sticking of cuttings.

including fertility, temperature, and moisture relations. Plant scientists are now examining the microbiology of the root environment with the same enthusiasm. Nurserymen should be aware of the developments in mycorrhizal research in the near future, as we learn more about the mycorrhizal relations of the commercially important woody plants.

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PETER VERMEULEN: Did you say methyl bromide will destroy mycorrhizae?

STEPHEN VERKADE: Methyl bromide at the normal rate is likely to destroy mycorrhizae.

DALE MARONEK: You find that some spores are resistant to fumigation. Also when you fumigate you fumigate to only a certain level. The roots have the capacity to go below that level and actually pull the mycorrhizae back up into the bed.

INDOOR AND OUTDOOR PROPAGATION OF JUNIPER AND ARBORVITAE

PLATT W. HILL AND BRIAN THOMAS

D. Hill Nursery Company
Union, Illinois 60180

In the last 10 years, D. Hill Nursery has moved its growing operation which has blessed us with the opportunity to install new propagating facilites. In 1979, we constructed new greenhouses and growing frames with the idea in mind that we wanted to shift emphasis on production of conifers from inside energy intensive processes to outdoor less energy intensive techniques.

THE INDOOR FACILITIES

Our greenhouses are of the double poly type with fiberglass sidewalls. We root our cuttings in beds 6.5 × 90′ long by 7.5″ tall which are constructed as follows:

1. We lay 1″ of styrofoam at the base of the bed for insulation.
2. The loops of ½″ PVC Pipe for heating are then laid on top of the styrofoam. The PVC pipe is on 6.5″ centers.
3. The sides of the bed are 2 × 8″ boards (Wolmanized), held in place by lengths of ½″ black pipe driven in the ground. The pipes are spaced on 6′ centers and clamped to the 2 × 8″ boards.
4. The heat pipe and styrofoam are then covered with 4″ of pea stone which provides drainage and aids in heat distribution.
5. A layer of woven polypropylene fabric covers the pea gravel. This prevents roots from going into the pea gravel and also prevents the rooting media from infiltrating the pea gravel.
6. We use sand as a rooting medium.
7. We hand mist all of our indoor cuttings.
8. Depending on outside temperatures, we circulate water under the beds at between 105 and 125°F.

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THE OUTDOOR FACILITES

Our outdoor rooting facilities begin with a standard 17 × 100′ hoop house which doubles as support for shade cloth in the summer and poly in the winter. The floor of each house has a 1% pitch and 6″ of pea gravel for drainage.

Inside each house are two beds 6.5 × 100′; they are separated from the sides of the hoop house by a 6″ air space. The beds use 1 × 6″ boards for sides and are filed with 3″ of composted hardwood bark covered by 2″ of sand.

Our mist system uses a whirl-jet type nozzle because we feel that they are more resistant to clogging then the "pin hole" type nozzle we have used in the past. It also produces a slightly heavier droplet which is more resistant to wind drift. The nozzles are installed on vertical risers coming from a supply pipe on the ground. The nozzles are set level which prevents the line from dripping when the valve is off; it also prevents the line from filling with air so when the valve opens all nozzles start misting at once. This system allows us to use a very short mist duration time and still get uniform coverage. Each house has one 2″ main solenoid valve to control the mist, but the mist for any 50′ section of a bed can be turned off by a manual valve if the cuttings in that quadrant have rooted more quickly than cuttings in another section of the house.

Our time clocks are 6 station time clocks which allow us a wide variety of mist duration and interval adjustments. The connections of the solenoid valves to the mist clocks are made through terminal strips, so if a station fails we can wire the solenoid to another station with a minimum of down time.

TAKING CUTTINGS

In years past we have always taken our juniper and arborvitae cuttings from early fall through winter and applied bottom heat to root them. However, with the rising cost of fuel to heat our greenhouses, we are expanding our use of non-energy or unheated greenhouses to propagate junipers and arborvitaes. This year we took all of our junipers, *J. horizontalis* cultivars, *Juniperus chinensis* 'Hetzii,' and all of our *Thuja occidentalis* cultivars in early spring through summer, and the balance of junipers in the fall of the year. This has eliminated the need to take cuttings during the coldest times of the year, thus enabling us to field-make all of our cuttings which allows us to make a greater number of cuttings per man hour.

Our procedures for field-making cuttings are as follows:

1. We take the cutting 6" in length and strip the lower 2" of foliage away. By doing this we wound the cutting.

2. We then place 25 cuttings into a bundle which is held together by placing a rubber band around the ends of the cutting.

3. This makes for easy handling and counting: our people average 800 cuttings/man-hour. The bundles are stored in moist burlap sacks by each individual and collected and counted hourly throughout the day.

4. When the bundles are brought in to be stuck, they are immediately immersed in a Captan-Benlate mixture. The mixture contains 2 lbs of Captan and ½ lb of Benlate/150 gallons of water After being washed, they are placed into a wire basket to drain.

5. The bundles are then individually dipped into IBA. We use a liquid concentrated dip made of IBA crystals dissolved in alcohol and distilled water. The strengths vary between 600 and 5000 ppm; each bundle is dipped for 5 seconds.

STICKING CUTTINGS

All the cuttings that are taken during the day are stuck that same day. This is so the base of the cutting is never given a chance to dry out and enables the cutting to absorb the IBA at a faster rate. This gives us a more even distribution of rooting throughout the bed.

When sticking the cuttings, we make a trench 1½" deep and place the cuttings in it. They are spaced according to the type and size of the cutting. When the row is complete, we place a board along the length of the row and tap it with hammers to close the tench up tight. Our people stick an average of 900 cuttings an hour. After they are stuck they are watered in thoroughly to help insure that air cannot dry out the base of the cuttings. After a complete bed is stuck, it is drenched with a mixture of Dexon and Benlate (2:1).

CULTURAL CARE — OUTDOOR CUTTINGS

For our outdoor propagation we depend on an automatic mist system that is reliable, consistant and relatively free of problems. The time clock allows us to adjust the frequency of mist from 2 to 64 minutes and duration of mist from 4 to 16 seconds. We cover the entire hut with 47% shade cloth to reduce the sun's intensity.

Along the length of the hut we have attached 1 × 3" boards, 36" from the top of the side board, and staple plastic to it for wind protection. The cuttings are sprayed bi-monthly with fungicides used in rotation as a preventative measure against disease. Depending on the cultivar we get root initiation in 4 to 8 weeks.

CULTURAL CARE — INDOOR CUTTINGS

When propagating indoors we feel there is no need for an automatic mist system. Due to the changes in the environment, we manually mist all of the cuttings. Working in an enclosed greenhouse, we also have the ability to control the humidity to a certain extent. Throughout the fall and winter, we carry 70 to 100% humidity. To measure the relative humidity, we use a precision hygrometer that we monitor closely throughout the day. It aides us in determining the frequency of mist. Our bed temperatures are kept between 65 and 70°F, and our air temperature between 40 and 50°F. Our indoor cuttings are also sprayed bimonthly with fungicides. Depending on the cultivar we get root initiation in 2 to 10 weeks.

RESULTS AND COMMENTS

We, as well as everyone else, strive to get a maximum strike from what we propagate. This past year we had excellent results with the arborvitates, a take of 90%. Results with the outdoor propagated junipers were not as good. We had about 50% that rooted and 25% that just callused. We attribute the poor take to not getting the cuttings in earlier, and having to take many of the cuttings from our container stock which was high in nitrogen due to the constant liquid fertilizing. Our cuttings inside have usually yielded a good strike of 75 to 80% overall. We feel we have only made it to first base on the outside propagating technique and hope to be rounding third and heading for home in years to come.

THE HYDROSOLARIC GREENHOUSE — A NEW GROWING AND PROPAGATING ENVIRONMENT

J. BEN-JAACOV [1], A. HAGILADI,
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Abstract. A favorable growing and propagating environment was created in a hydrosolaric greenhouse This closed greenhouse was composed of a solar energy harvesting system and hydroponics Energy collected by the greenhouse air from the sun during the day was conserved in the growth solution which released the energy during the night

[1] Presently on leave at the Agricultural Research Center, Rt 3, Box 580, Apopka, FL 32703

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The cultivation of greenhouse crops faces the challenges of increasing cost of energy and providing a suitable, economical growth medium. In many cases, especially for propagation and cultivation of young plants, high humidity in the greenhouse is important, a condition difficult to create in hot, dry climates.

Solar heating and cooling of greenhouses is still an uneconomical proposition. Even with the present price of fuel, the most advanced solar heating technology cannot heat a greenhouse cheaper than conventional methods (5).

Some hydroponic systems provide a suitable and economical growth medium. Many of these systems however, require an accurate control and any failure may cause substantial losses.

The main method to increase the humidity in dry climates is the use of mist. This method is unsatisfactory when only poor quality water is available. Salt deposition on leaves, especially of foliage plants, reduces their quality.

Maintaining a proper environment for plant growth in a "conventional greenhouse" (Fig. 1a) is achieved by wasteful technology. During the day, excess heat in the greenhouse is removed and discarded by ventilation, while expensive fuel is used to reheat the greenhouse at night. Watering and fertilizing are done by passing growth solutions through the growth medium. The excess water and fertilizers are leached out and discarded. This technology, in addition to being wasteful, contaminates the underground water with fertilizers.

The present report describes a growing system which tries to provide a suitable growing environment using more efficient technologies.

MATERIALS AND METHODS

The System and Environmental Conditions Obtained. As the name hydrosolaric ("hydro" from hydroponics, and "solaric" from solar energy) implies, 2 principles were involved in the operation of this closed greenhouse system: *first*, using solar energy harvested during the day to heat the greenhouse during the night; and *second*, growing plants hydroponically (Fig. 1b).

The hydrosolaric system was built as a closed quonset-form greenhouse, 3 m wide, 4 m high, 20 m long, and covered with a double layer of polyethylene. In order to adjust the environment for the cultivation of house plants, the entire greenhouse structure was shaded to reduce the light intensity by 50% to approximately 5000 ft-c maximum. The greenhouse floor was dug to a depth of 80 cm, and the walls of the excavated area were supported by concrete blocks. The entire area (floor and walls) was covered with black polyethylene (0.2 mm thick). The pond was

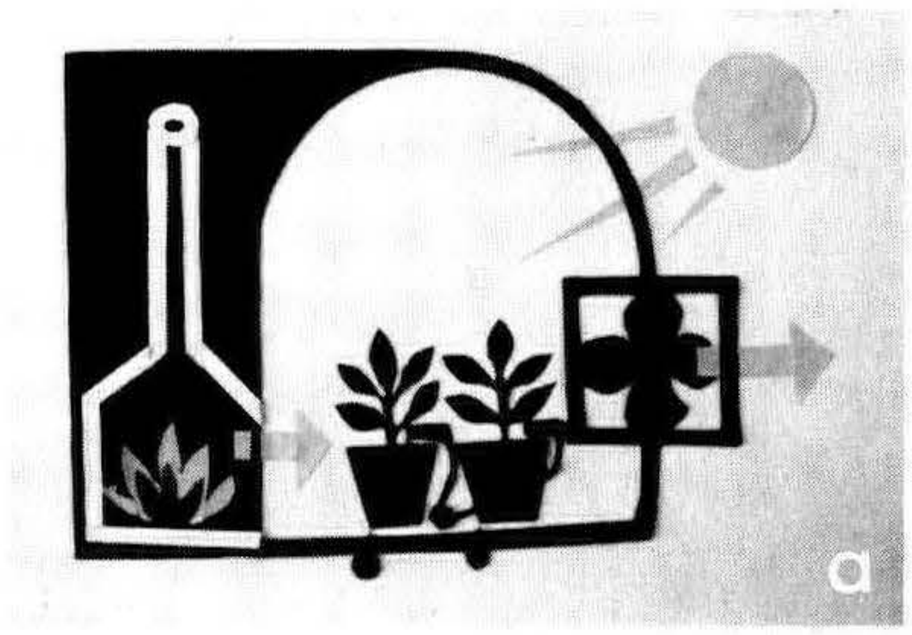

Figure 1a.
Conventional greenhouse system.

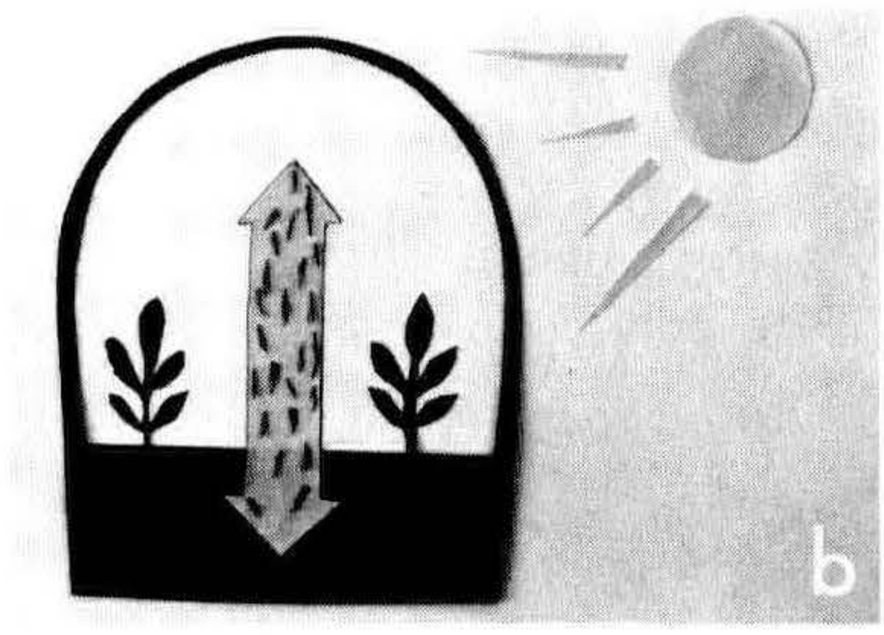

Figure 1b.
Hydrosolaric system.

filled with $38m^3$ of growth solution. The water surface was covered with styrofoam boards (10 cm thick) which floated on the water. Plastic baskets (40 cm × 28 cm × 17 cm deep) filled with coarse volcanic gravel (Fig. 2a), were placed in holes cut through the styrofoam boards. The floating styrofoam boards served as a path for walking between the plants, as well as a floating raft which kept the upper edge of the baskets at water level. (1,2,3,4).

The heat exchange unit was placed at the northern end of the greenhouse. In order to increase the surface exposure of the solution, it was pumped and forced through nozzles, located at the upper end of the heat exchange unit. Ventilators placed on the wall, between the heat exchange unit and the growing area, created an air circuit through the waterfall. As a result of this, two closed circuits were formed in the greenhouse: a growth solution circuit which began with the solution pumped from the southern end of the pond and then dispersed through the heat exchange unit and back to the pond; and the air circuit, with the movement of the greenhouse air through the heat exchange unit back to the greenhouse.

The close contact between the growth solution and the air moderated the greenhouse air temperature; cooling it during the day and heating it at night. The only source of heat in the hydrosolaric system was the natural sun energy. The daily amount of heat accumulated in the greenhouse was dependent on the amount of solar energy radiated into the greenhouse, on outdoor temperature, and on wind velocity — all natural, vari-

Figure 2a.
Four month old seedlings of *Philodendron bipinnatifidum* grown in hydrosolaric system: (a) plant growing in plastic basket filled with coarse volcanic gravel.

Figure 2b.
Plant after being removed from basket.

able and uncontrollable factors. To obtain optimal environment in the greenhouse at each given set of these natrual, outdoor conditions, it is necessary to distribute, wisely, the daily available energy accumulated in the greenhouse, between the air (by day and night) and the growth solution. The control of a proper distribution was achieved by the use of two thermostats: one determining the day temperature above which the pumps started to operate, thus transferring the excess heat from the air to the solution, and the other determining the night temperature below which the pump started to operate, thus transferring heat from the warm solution to the cold greenhouse air. When heat energy was limited (on cold nights and cool cloudy days), the thermostats were set for maximum 22°C and minimum 12°C, whereas when heat energy was not limited (on sunny warm days and warm nights), the thermostats were set for maximum 25°C and minimum 18°C. Setting the thermostats at too low values (22°C and 12°C) after hot days and nights caused overheating of the growth solution and thus reduced the oxygen level in it. On the other hand, setting the thermostats at too high values (25°C and 18°C), on a cloudy, cool day, and cold night exhausted the heat supply

early in the night, leaving the rest of the night without any heating. On extremely hot days, a ventilating window was opened at the northern upper part of the heat exchanger, which was used as a fan and pad cooling system. Examples of the ability of the system to heat and cool the greenhouse are presented in Table 1 The hydrosolaric system maintained air temperatures of 10° to 32°C, a relative humidity that dropped below 100% for only 4 hr during mid-day, and growth solution temperatures of 13° to 25°C.

Table 1. Temperature and relative humidity (RH) in the hydrosolaric greenhouse during cold and hot days

	OUTDOOR		INDOOR		
	Air		Solution	Air	
	Temp (°C)	RH (%)	*temp* (°C)	*temp* (°C)	RH (%)
Cold — Winter	2 — 15	52	13 — 18	10 — 23	81 — 100
Hot — Spring	19 — 38	45	18 — 25	18 — 32	76 — 100

Due to the large volume of nutrient solution (0.6 m^3/m^2 growing area), once a week testing and minor adjustments were sufficient to maintain relatively stable levels of nutrient and pH.

The hydrosolaric greenhouse was completely closed all winter, which permitted the introduction of CO_2. A level of 1000 ppm CO_2 was maintained constantly in the greenhouse.

RESULTS AND DISCUSSION

Plant Performance. A broad range of plant material was examined for its suitability for the hydroponic system. *Philodendron bipinnatifidum, Ficus benjamina* and *F. lyrata, Gardenia* augusta *(syn.:G. jasminoides), Anthurium andraeanum* and *Brassaia actinophylla* grew outstandingly well. Other species, including: *Ruscus* spp., *Acacia cultriformis,* × *Fatshedera* lizei and *Eucalyptus* sp. were tried but did not react favorably to the high humidity or to the hydroponics.

The growth of species well adapted to the hydrosolaric system was unique and different from the growth of the same species in conventional greenhouses in the following ways (Fig. 2a and b):

a Rapid growth rate: In *Philodendron bipinnatifidum,* for example, after a two month acclimatization period in which growth was minimal, leaf area increased 5 times in a period of 1 month (from 200 cm^2 to 1000 cm^2 per plant).

b. Very large leaves: Very large leaves were produced in the hydro-solarically grown *Philodendron bipinnatifidum*, *Brassaia actinophylla* and *Ficus lyrata*.

c. May offshoots: Plants of *Philodendron bipinnatifidum* and *Anthurium andraeanum* produced many offshoots. The development of offshoots was apparently stimulated by the special environment created. The crowns of the plants were exposed, well aerated and under conditions of high relative humidity.

d. Abundance of lenticles and aerial roots: Stems of *Brassaia actinophylla*, *Philodendron bipinnatifidum* and *Ficus* spp. were covered with large number of relatively large lenticles. *Brassaia actinophylla* plants produced large number of aerial roots.

Some of these phenomena may have some practical implication in the propagation of these plants.

CONCLUSION

The hydrosolaric system is a closed growth system which permits CO_2 enrichment of the greenhouse, air maintaining a very high level of humidity, and a reasonable growing temperature (without artificial heating) for foliage plants during the Israeli winter.

The 2 components of the hydrosolaric system hydroponics and solar heating of the greenhouse can be separated and thus, the system can be used just to control the greenhouse air atmosphere (heating, cooling, raising humidity, and maintaining a high CO_2 level), and the plants can be grown in conventional solid media.

The hydrosolaric system supported very rapid growth of excellent quality tropical foliage plants without the need for any heating. It creates a favorable environment for growing foliage plants for the production of stock plants, and for rooting of cuttings.

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QUESTION BOX

The question box session was convened at 4:00 p.m. with Ralph Shugert and Bruce Briggs serving as moderators.

MODERATOR SHUGERT: Does anyone have any comments to make about gel seeding? Does anyone have an address for a gel source?

GLEN LUMIS: We are doing a little work with black spruce. If anyone would like to write me I can put them on to some sources that can help them. My address is Department of Horticultural Sciences, University of Guelph, Guelph, Ontario, Canada.

MODERATOR SHUGERT: During the tour of Weston Nurseries we saw the rooting of *Pinus mugo* cuttings. Please explain your procedure and do you take spring cuttings?

KATHLEEN FREELAND: We have not tried spring rooting of cuttings. We take them in the winter with good success. We are going to try candles next spring. The cuttings are 3-4 inches long and from current seasons growth. We are using 1% hormone. We have also experimented with Jim Wells Synnergol from England. We will know better next year how it worked.

MODERATOR SHUGERT: Question for Ed Mezitt. Would you explain your method for forcing *Malus* into leaf and flower for shows?

ED MEZITT: The secret is that they should have a good root system. It will take about 4-5 weeks at a cool temperature of 50-55°F The plants need syringing 4 times per day to prevent drying of the wood.

MODERATOR SHUGERT: How do you help *Acer griseum* trees to produce viable seeds?

GUS MEHLQUIST: I have had no experience with that species but know that the seeds do not germinate because they lack embryos. That often happens with isolated clones of various species and I presume that results because they require cross pollination with different clones.

BILL FLEMER: The plant appears to be highly self-sterile. If you are going to get seed set you are probably going to have to plant a large group of different clones in close proximity to each other for cross pollination.

GARY KOLLER: There was a very good study done in Europe on flowering and sexual expression in maples. The study showed that in *Acer griseum* there is a flowering sequence problem in an individual plant. First you have the male flowers opening and then the female flowers open. In a cluster of different clones you would hopefully have different clones with different flowering sequences pollinating each other.

MODERATOR BRIGGS: Do nutrients help root initation when applied during rooting?

JOHN McGUIRE: No. I personally feel that the nutrient status of the stock plant at the time the cutting is taken is more important.

DICK ZIMMERMAN: In tissue culture we cut the nutrient concentration in half for rooting.

PAUL READ: With many of our tissue culture propagated plants we get our best results when we cut the nutrients out completely and root in sphagnum peat. We move them along as fast as possible with bottom heat and high humidity. I think the physical conditions of the medium are more important for rooting than nutrients with many plants, and aeration probably is one of the big things.

BRUCE BRIGGS: I would like to throw something out for your consideration. In the west they are using Osmocote in their propagating medium and getting better results. Also we made a mistake in tissue culture and doubled our phosphate concentration and we increased our rooting tremendously.

MODERATOR SHUGERT: Has anyone propagated birch from cuttings?

DAN MILBOCKER: We have rooted birch under high humidity conditions when the plants are young. After they start to produce catkins they become more difficult. They can be rooted in June and also in the fall just before leaf drop, especially with river birch.

JOE CESARINE: Birch roots very easily from cuttings. I will send the editor the technique we have developed. (Ed. Note. The information from Joe Cesarine can be found at the end of the Question Box session.)

JOERG LEISS: European birch roots quite readly from cuttings taken in late May and June, and treated with No. 3 Hormodin under mist.

MODERATOR SHUGERT: To anyone producing *Acer tegmentosum*. Should all propagation, liner and field production be carried out in sun or shade. The plant appears to be very limited in growth when in full sun.

TIMOTHY BROTZMAN: We propagate the plant under shade cloth.

MODERATOR SHUGERT: Has anyone propagated oaks from cuttings?

DALE MARONEK: Dr David Morgan at Texas A&M has been working on southern oaks.

MODERATOR SHUGERT: Is anyone rooting *Kalopanax pictus* from cuttings?

BILL FLEMER: We have grown it from root cuttings but have never been successful with stem cuttings. Dig up large sections of roots in the spring as soon as the frost is out of the ground. Cut the roots into 3-4 inch pieces and stick vertically in the medium with the distil portion down in a cool greenhouse.

MODERATOR SHUGERT: Question for Frank Guoin. When should you remove the plants from under your propagation tent in order for them to harden off for winter storage when propagating in the summer time? What fungicide do you use?

FRANK GUOIN: For the summer propagated plants we took the cuttings in early July. The longest we had cuttings under the tent was with viburnum and they came out in late August. These were overwintered without difficulty when covered with microfoam around Thanksgiving time. With the winter propagated cuttings we uncover everything on March 15 and leave it sit until it starts to grow. We use Captan (2 lbs) with Vaporgard as a sticker. Problems can develop if the thermoblanket is left on to long in the fall or spring so we try to get it off as fast as possible.

MODERATOR BRIGGS. What is the best way to cutting-propagate *Magnolia heptapeta* (syn.: *M. denudata*) and *M. salicifolia*?

PETER VERMEULEN: We have rooted *M heptapeta* (Syn.: *M. denudata*) in our area about the last week of June or the beginning of July just as the first flush of growth is ending. Terminal cuttings are used with all leaves removed except the top 2-3 leaves. The leaves are generally cut because they are so large. The auxin used varies. We have used Hormodin No. 3 or a mixture of 4% IBA and 4× CutStart at equal parts and 1/16 by volume of a fungicide such as Captan. The medium can be either sand or sand and peat. Bottom heat is 65-70°F.

MODERATOR BRIGGS: Has anyone rooted *Magnolia kobus*?

JOERG LEISS: Take them about the first week of July, give them a heavy wound, 2% hormone powder and stick them in the greenhouse. Rooting will occur in about 4 weeks.

MODERATOR BRIGGS: Has anyone been able to root *Cedrus deodara* 'Kashmir' and *C. atlantica* 'Glauca'?

JACK ALEXANDER: We have been experimenting with the rooting of *C. deodara* 'Shalamar' and our best results have been obtained with a quick dip of 10,000 ppm IBA. Cuttings were taken in December-January and placed in a sand-perlite medium at 70°F under a poly tent.

PAUL BROYLES: We take 6 inch cuttings of *C. atlantica* 'Glauca' about the 15th of December and use perlite as the rooting medium. Hormone is supplied as a 3-4% quick dip.

BRUCE BRIGGS: We had, out west, about 10 years ago a grower who used outside cold frames with heating cables and got *C. deodara* to root like weeds. Cold tops and hot bottoms worked very well.

MODERATOR BRIGGS: Is anyone growing *Daphne* in containers? If so, what is a successful soil mix.

BRUCE BRIGGS: I have talked to Jim Cross and he keeps them on the dry side and uses a medium that drains well. Some members of the group will take wetter feet and these should be tried.

RALPH SHUGERT: I would just like to comment on the rooting of *Daphne* cuttings that I saw on our tour of Weston Nurseries. The cuttings were stuck on November 11 and they had roots forming already. The key, to me, in his rooting of the *Daphne*, was that the mist nozzle was blocked off above the cuttings.

MODERATOR BRIGGS· has anyone worked with an acetone dip prior to IBA treatment?

DAVE BAKKER: We tried it with some hard-to-root junipers but it did not work.

VOICE: We have tried it on may cultivars of dwarf spruce and the only ones that rooted were the untreated cuttings.

MODERATOR BRIGGS: Has anyone rooted Douglas fir successfully?

JOERG LEISS: We have successfully rooted *A. koreana* but we got prostrate forms.

FRANK GUOIN: We did some Douglas fir two summers ago and found wide clonal differences from 100 to 0% rooting.

BRUCE BRIGGS: In the west they have selected out some clones that will root. There is a dead spot in our area in October-November. Our best time is after the cold weather about the first of March.

MODERATOR SHUGERT: What is the best production techniques for the successful propagation of *Juniperus procumbens* 'Nana' (Syn.: *J. chinensis* var. *procumbens* 'Nana')?

JOHN SPARMANN: It is not a problem with us. We have made summer and winter cuttings, stuck them in a sand, peat and perlite mix with Homodin No. 3 and obtain 100% rooting.

PETER VERMEULEN: I will second what John said. One concern though is overwatering because they will rot easily. We have also stuck cuttings in late August and September with heating cables. I have observed frost on the top of the cuttings with no detrimental effects. They seem to like cold tops and a warm rooting zone.

JOERG LEISS: We had a problem until we went to very small cuttings treated with Hormodin No. 3.

MODERATOR SHUGERT: What is the best procedure for propagating *Juniperus chinensis* 'Keteleeri'?

CARL ORNDORFF: We have no problem. Cuttings are taken in late November or December and placed in a greenhouse with bottom heat and very coarse perlite as the medium. No hormone is used.

JOERG LEISS: We gave up rooting that plant because it is not the same plant on its own roots as when grafted.

MODERATOR SHUGERT: Has anyone propagated *Corylus colurna* by cuttings, and if so, by what technique? What experiences can be shared about this plant?

WAYNE LOVELACE: It is a wonderful plant. We have only been able to propagate it from seed. We established a seed source block 20 years ago but have not obtained any seed yet.

JOERG LEISS: It is extremely drought tolerant and is used as a street tree in Europe. We are propagating it as seedlings.

MODERATOR SHUGERT: When junipers, taxus, etc. are grown under accelerated growth, how do you harden them off for winter? Do they harden off completely or do you have trouble?

GLEN LUMIS: You have to be particularly careful with *Taxus* because if they do not set buds they will not grow the next year. You have to get the lights off early.

MODERATOR SHUGERT: What would cause yellowing of *Chamaecyparis* seedlings grown under 53% shade, in a sand-peat medium, and well fertilized?

PETER VERMEULEN: Often 2nd year foliage under very heavy shade will show yellowing. A medium that is too wet could also be causing root rot as we have found.

MODERATOR SHUGERT: Does anyone have a mechanical planter for planting dormant perennials grown in peat pots? Also, does anyone have a mechanical way of breaking up peat pots before planting them in the field?

MICHAEL DODGE: No. We have sent samples to Holland Transplanters this fall and they are going to design us a holder for the peat pots. We hope they will incorporate a means of breaking up the pot.

JEORG LEISS: The use of Aqual Grow will aid in the more rapid breakdown of the peat pots.

MODERATOR SHUGERT: Does anyone know of a machine that will clean the tops off perennials after they are dug without damaging the crowns.

MICHAEL DODGE: We use a mower to cut the tops off

MODERATOR SHUGERT: How effective is soaking or submerging the entire leafy cuttings in an IBA/fungicide dip prior to sticking?

MICHAEL DODGE: I know of a nursery in Ohio that does it and we are trying it this year but have no results yet.

RALPH SHUGERT: I know it is common practice for many nurseries to fungicide-dip their cuttings

BILL FLEMER: I am disturbed about the idea of dipping cuttings in solutions of IBA or fungicides prior to sticking I think we are laying ourselves open to enormous trouble. As you know the EPA almost succeeded in banning IAA and IBA from use. They are suspect as being carcinogenic or cancer forming. The sloppy practice of dipping in hormone and fungicide solutions and then having employees handling the cuttings is extremely dangerous. It is dangerous because you lay yourself open for lawsuits from employees who get cancer or lung disease or some other disease. They might start to look at their employer as a good place to start suing for damages. You need only talk to Jim Wells who nearly died from working with fungicide-treated cuttings to find out what can happen. No one should dip cuttings in hormone or fungicide and then work with them. Cuttings dipped in hormone powder is the best way to go. With fungicides, stick the cuttings first then drench with proper precautions.

MODERATOR BRIGGS: Is there a commercial product for the inoculation of mycorrhizae for container-grown plants, such as pine?

DALE MARONEK: No. However, Abbott Laboratories, Chicago, IL, will supply some on a limited basis for a price which will get your started. You can then produce your own

MODERATOR BRIGGS: Question for Tom Pinney. Shouldn't the newly transplanted plants be watered in heavily after planting to increase root development? Why not install Rain Bird sprinklers behind the planter and save all that labor?

TOM PINNEY: I was afraid someone would ask that question. Watering is one of those things that I consider more an art than a science. Overwatering will probably kill more plants than underwatering. The roots must have air for proper development. We bring our soil to the proper water level for the individual species before we plant. That is a cardinal rule with us You can get a little sloppy after root regeneration, but before can lead to growth retardation.

MODERATOR BRIGGS: Question for Tom Pinney. What pH do you use in your growing mix for Black Hill spruce, *Abies concolor*, and for Colorado blue spruce?

TOM PINNEY: I would have to guess but I think we grow them all at about the same pH 4.5-5.0. I know you can grow the Colorado blue spruce higher.

MODERATOR BRIGGS: How do you get mugho pine to make more than 2 flushes in a growing season?

BRUCE BRIGGS: In the west there was some research that showed very high fertility could keep them growing. They were using slow release fertilizer at 15-18 lbs/yard.

MODERATOR SHUGERT: Would *Malus baccata* or *M. sylvestris* be the better understock for grafting crabapples?

BILL FLEMER: *Malus baccata,* because it is slower growing and does not sucker as much. *M. baccata,* however, has a less fibrous root system and is more difficult to transplant.

BOB SIMPSON: Seed source with *M. baccata* is very important. An isolated seed source is one thing but cross pollinated *M. baccata* will give extremely variable understock.

MODERATOR SHUGERT: Has anyone had any experience with using *Pyrus calleryana* as an understock for edible pears?

BILL FLEMER: We have tried it and noted that it dwarfed the scion and also reduced fruit production.

PROPAGATION OF BETULA

JOSEPH CESARINI AND BEN MINAMOTO
Phyto Ecology
P.O. Box 303
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We used to propagate clones of *Betula pendula* by grafting them during the winter months on seedlings of the same species. We produced our own understock by collecting our own seed. We planted them in a greenhouse at 65°F in flats with a mixture of perlite and peatmoss. The seeding was done during September or October.

The seeds usually germinate very rapidly and with a little help from liquid fertilizer they grow very well all winter long. About May, when the danger of frost is over, we pick them off into 2¼" rose clay pots into our regular potting soil consisting of sand and peat moss with Osmocote, and place them outside in a growing area. By fall, they are the thickness of a pencil. Only a few weeks before grafting we bring them in the greenhouse. The greenhouse temperature is maintained at 65°F and we used a

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modified veneer graft. This we find is the best way to produce understock because an unestablished understock is a sure failure in grafting birches.

I never had the opportunity to visit some of the large shade and ornamental tree growers on the west coast. I was told that some of the growers produce clones of birch by budding them close to the ground in field rows. They use large well established seedlings and use the same to stake the growing bud the following year. In other words, after the budding is successful they don't cut off the understock but girdle the seedlings just above the bud. The growers leave it there so it can be used as a stake.

In my opinion, grafting or budding is a long and costly task if you take into consideration greenhouse space, understock production, and unpredictable results. With this in mind, we were looking for a better and a more economical way. One year when collecting scions for grafting we came across some seeds of *Betula pendula* 'Youngii', 'Fastigiata' and 'Purpurea'. We planted them in separate trays in the greenhouse just out of curiosity. The only one that showed some promise was *Betula pendula* 'Purpurea' which had quite a few red seedlings. I feel that if plants of this clone were isolated, a good percentage of red seedlings could be obtained from seed It would be interesting also to try some seeds of other clones from isolated specimens where cross pollination does not occur.

Looking through some catalogues from another country, we noticed that they were offering *Betula nana* as rooted cuttings. I had a little plant of it in my collection and tried a few cuttings and the results were amazingly good after a few failures. We felt that if *Betula nana* could be rooted then other birches might also root. We tried every combination of media, hormone, timing, and size of cutting till we found a combination that gave good results. We have been doing this for only a short time and the little bit of knowledge we have gained, we would like to share with you.

Source and type of cuttings. The stock plant should be healthy, vigorous, and free from insect and disease pests. The cuttings should be from current growth about 6 to 8 inches in length. A very shallow side wound is beneficial. Cuttings root best when taken from previously rooted plants.

Time of taking cuttings. A set date cannot be given because it varies according to the growing season. However, I take the cuttings just as the last leaf on the cutting reaches full size and the last bud has not fully developed

Rooting media. Perlite and peatmoss are mixed in a ratio of one 6 cubic ft bale of Canadian peat and two 4 cubic ft bags of coarse perlite.

Hormones. Hormodin No. 3 or 1% indolebutyric acid in talcum is satisfactory. This system works so well that we root the cuttings right in peat pots after adding 3 or 4 holes per pot for drainage.

Dormancy period. We found that in order for the cuttings to grow well the following year, they require a dormancy period. We place the well-rooted cuttings in a greenhouse where we try to keep them at a temperature of 32°F during the winter months. They start to grow, about late March or April, as the weather warms up and the days get longer. When the danger of frost is over the rooted cuttings go in containers and continue their growth outside. By following the combination of these old but simple rules, birches can be grown from cuttings.

For years nurserymen have tried to grow a perfect clump of birch. Nothing is more annoying to me than to see a clump of birch with 4 or more seedlings, one a 2 inch caliber pure white, another one ½ inch caliber and reddish brown, and the next a few other sizes and colors in between. Those seedlings were matched together when they were 6 to 8 inches high. Every seedling is a genetic variation and, as in a human being, it is hard to say how one will mature. We know that birches will root. If we select a good plant, root cuttings and then plant 3 to 4 rooted cuttings together, we can have uniform clumps.

Thursday Evening, December 11, 1980

The Thursday evening educational program on applied aspects of teaching plant propagation labs was convened at 8:00 p.m. with Dr. Elton M. Smith serving as moderator.

THE "KNOW-HOW" IN PLANT PROPAGATION EXPECTED FROM COLLEGE GRADUATES: SEED PROPAGATION

HUGH STEAVENSON
Forrest Keeling Nursery
Elsberry, Missouri 63343

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our gross sales. During this period we have employed a good many college graduates, perhaps a score or more, mostly with degrees in horticulture. In recent years we have enjoyed the stimulating experience of having groups of college-level trainees at our nursery during the summer and also spring and fall periods. Today our work force numbers about 100 of which 10 are college graduates, most with horticultural training. These college trained people have management, supervisory, sales and technical responsibilities.

Interestingly enough, I can never recall quizzing any of these people, prior to their employment, on their knowledge of or expertise in seed propagation. This might be considered a lapse in our interview procedures.

But is it really? We have spent a couple score years developing our seed propagation techniques and each year modify or change some procedure based on new knowledge or experience. Can we realistically expect any new graduate to possess expertise in a field of practice it has taken us so many years to develop?

What then do we look for in college graduates when employment slots open? Obviously we are looking for help that can assist us down the success road — people who can help us make a buck, if you will. Available statistics indicate that only about half of college graduates stick with their first job more than a year. It's a matter of young people finding their nitch. But this is very costly to the employer. It may be a few years before a new graduate in a technical, sales or management situation really becomes profitable to his/her employer. So, among other things, we like to assess the likelihood that a mutual affinity will present a fair chance for career employment. More on this later.

Of course we look at grade average and scholastic and extracurricular record. A candid talk with principal instructors or a counselor can be most helpful in assaying his/her potential. Part-time, summer and other work experience and references are, of course, important. Picking up the phone and discussing the applicant with prior employers or instructors can be more meaningful than written references.

For production work, other things being equal, a farm background is desirable. We are in-ground or field growers. It is amazing how long it takes someone who has not worked with the soil to understand when tillage conditions are right and when working soil at the wrong time can be disastrous. Farm youths also often have a discipline of good work habits.

In any phase of plant propagation continuing diligence is a must. The individual interested in 9 to 5 hours and long, free weekends should surely turn to other fields of employment, such as banking, brokerage or the like. We have a saying at our place

that you can only kill 'em once. It takes only one unattended clogged mist line or a burner out in the greenhouse to ruin weeks of otherwise superb propagation effort.

Not that seedage or other propagating endeavor need be a drudgery. I have been engaged in a number of other pursuits before becoming a full-fledged nurseryman and can honestly attest that none were as satisfying or fulfilling. With good back-up personnel the propagator need not be chained to his duties. But when that alarm rings at 3:00 a.m. indicating the burner has flamed out in the greenhouse, somebody better respond to get the emergency heaters going.

Enthusiasm and esprit are probably more important in sales or leadership situations. But as any college graduate may move to these areas such qualities, along with basic honesty, a sense of company loyalty, and other good personal attributes are always sought in prospective key employees.

Earlier I mentioned career employment and the turnover problem. Like many or most production nurseries we are located in a small rural town, lacking many amenities of city or college communities. More than once we have encountered situations where the employee was happy but where the wife, perhaps city bred, was unhappy in the "hick town." This situation can be expected to lead to the loss of a promising employee. For this reason we favor key employees with their roots down. If the employee, and especially the wife, has her people in the community the stability factor is greatly enhanced.

Recently I visited what has to be the most modern field seedling nursery in the northwest. It was between seasons and the operation, which would employ 60 or more during peak activity, had only the manager, assistant manager and a couple of other hands working. The manager was a young woman with a horticulture degree and a nursery background. Her assistant manager was a younger woman recently graduated from a horticulture school. They were both maneuvering tractors around, getting set for fall seeding and harvesting. I asked the manager how her crew would break down between male and female workers. She thought a minute and replied, "about 99% female. Aside from one handyman to do any real heavy lifting, women run the place. We do, however, bring in contract labor to pull seedlings at harvest time."

The past year our greenhouse seedage and vegetation propagation has been largely headed by a couple of women trainees, or internees would be the better description. They have done an outstanding job and I would be happy to hire either to head up this work.

I don't think any nurseryman expects any horticulture school

to turn out "experts," in whatever phase of propagation. If the educators can give us people who can think, who can communicate and who possess the disciplines on which expertise can be built that is all we should expect.

THE "KNOW HOW" IN PLANT PROPAGATION EXPECTED FROM COLLEGE GRADUATES: HERBACEOUS AND TISSUE CULTURE PROPAGATION

MARK CUNNINGHAM
Cunningham Gardens, Inc.
Waldron, Indiana 46182

I feel our universities are offering a well-rounded academic curriculum in horticulture education and in most cases very good programs in plant propagation. The basic information is offered; the student who is most interested and studious becomes the leader of tomorrow.

The universities cannot be faulted in graduating students who are not talented, employable people, ready to assume immediately the management responsibility of general propagation, whether it be the sexual or asexual propagation of evergreen or herbaceous plant materials.

If there is a fault that prevails in preparing students for immediate takeover of a progressive propagation program, it lies in too little practical, hands-on training. At Purdue, ten weeks of summer work in industry is required to obtain the horticulture degree. There should be at least two twelve-week work summers required; even then, the student will only be partially trained for major responsibility.

Tissue culture, perhaps better titled micro-culture, is highly technical A student desiring to work in this field must pursue special academic training, with courses directed toward this goal, over a two year period, or longer, before he or she is capable of lab management. A degree is not necessary for the culture transfer process There are greater opportunities in this field of endeavor for those who have attained at least a masters' degree in lab management

In my opinion the greatest values one should get out of college are; 1) learn to be a problem solver; 2) know where to get information; 3) keep an open mind to change; 4) keep updating knowledge.

Aside from the university degree, there are other qualifications required for serious consideration by industry for employ-

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ment. Among them, INITIATIVE, a willingness to take on responsibility and DEDICATION to the pursuit of excellence.

A few aspects of propagation a newly employed college graduate should know upon getting into his career, would be: knowledge of rooting media, methods of environmental control, auxins, timing of cutting harvest, preparation of cuttings, direct rooting vs. bed rooting, ability to synchronize work for year round schedules, fertility control, pH needs, and disease control. There are many many others.

Other things which are considered by employers are poise, warmth, personality, business sense, dependability, skill and punctuality. These cannot be taught easily — usually they're learned away from the school environment. Just where it starts, I don't know, perhaps at home or by a teacher who ignites the fire.

The universities are contributing greatly to mankind, but the individual, if he or she is to succeed, must match it with personality, desire and determination.

TEACHING PLANT PROPAGATION LABORATORIES: VEGETATIVE PROPAGATION

THOMAS A. FRETZ

Virginia Polytechnic Institute
and State University
Blacksburg, Virginia 24061

To be effective, plant propagation at the collegiate level must be designed as a lecture-laboratory course. The lecture-laboratory teaching mode enables students to acquire knowledge and become proficient with the fundamental skills and concepts involved in propagating horticultural crops.

Plant propagation in most universities is taught at the sophomore level, with few of the students having had the benefit of a practical nursery or propagation experience. In fact, more than 60% of today's undergraduate students are from urban backgrounds and may be experiencing propagation of plants for the first time. Consequently, laboratory projects must be designed to demonstrate the simplest concepts in regard to both asexual and sexual propagation.

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Initially, the students need to become acquainted not only with the plants to be propagated, but also with the equipment needed. Secondly, by conducting simple projects on the evaluation of rooting media or the effects of juvenility, wounding, or leaf area on root regeneration, the learning process can be reinforced to compliment the lecture material. Thirdly, labóratory projects or exercises should provide the opportunity to develop the basic propagation skills such as cuttage, grafting, budding, layering, propagation of specialized structures, and tissue culture, which are practiced in the industry.

In addition to the laboratory projects conducted at the university, it is extremely beneficial to arrange a tour of a commercial nursery where many of the demonstrated skills and practices can be viewed firsthand. For the greatest benefits, this tour should be in the latter part of the school term.

In teaching plant propagation, I have traditionally begun by introducing students to the intermittent-mist system during their initial laboratory session. This has been coordinated with lecture material (generously illustrated with slides on the construction and design of an intermittent-mist system) which includes a description and discussion of the equipment required, such as strainers, solenoid valves, types of mist nozzles, and mist-controlling devices.

It has next been a practice to take these same students on a tour of the university propagation facilities to see firsthand the equipment in the intermittent-mist bed, only to find the students confused and bewildered. Lastly, inorder to reinforce the learning process and to be sure the students fully understand the concepts of the intermittent-mist system, I ask them to design and prepare an itemized cost estimate for installing an intermittent-mist system, given some standard information, such as the propagation bed dimensions and location of the nearest water supply. During the course of the laboratory project the student is asked to:

- Prepare a rough sketch of the proposed intermittent-mist system.
- Calculate the total cost of the delivery equipment, including pipe, elbows, tees, unions, caps, solenoids, nozzles, and strainers needed to complete the system.
- Calculate the total cost of the various electrical mist-controlling devices, including time-clock controls, mist-a-matic, and electronic leaf systems.

To complete the project, I supply catalogs from the major horticultural supply houses and have examples of the various component parts of the intermittent-mist system in the laboratory classroom for student use and inspection. Students are asked to

prepare an itemized list of equipment necessary to build the system, including source of supply, item number, description, price per unit, quantity, and total cost as one might expect in preparing a purchase order.

At the completion of the project, students are asked to indicate which of the control systems they might use in their own nursery or greenhouse operation and why. Generally students choose the system that provides maximum flexibility at the least dollar cost.

I have observed that following this laboratory project, the intermittent-mist propagation facility simply is not taken for granted, but that students have a measure of respect for the costs and sophistication of the technology involved in vegetative propagation of cuttings. While I would be the first to admit that the next logical step would be for the students to gain hands-on experience by building an intermittent-mist system, that has not been possible with propagation classes often exceeding 100 students.

Once such understanding of the intermittent-mist system has been achieved, a number of additional laboratory projects have been developed to acquaint students with the other aspects of vegetative propagation. For example, the following laboratory projects have been designed to illustrate factors influencing root initiation and development on cuttings.

- Influence of leaf area at the time of propagation on subsequent root development.
- Reduction of water loss in cuttings and its effect on root development.
- The effect of cutting size and type of wood on root initiation and development.
- The effect of tissue age on root initiation and development.
- The effect of growth regulator concentrations and duration on root initiation and development.

All of the above laboratory projects are designed to illustrate one or more factors that influence root initiation and development. In most of the projects, we use plants that root quickly, like chrysanthemums, coleus, ivy, forsythia, or firethorn, so the students can see a response clearly and quickly. This also allows students to complete the laboratory project within 2 to 6 weeks, thus quickly reinforcing the lecture material, which is extremely important when teaching propagation on the quarter system.

Lastly, a series of laboratory periods are devoted to demonstrating and giving students the opportunity to develop their skills in cutting propagation, grafting and budding, air-layering, propa-

gation of specialized stems, and tissue culture. The intent of all these laboratory projects and demonstrations is to acquaint students not only with the skills necessary to perform the task, but also to be sure they understand the terminology, the type of plant material used, the time of the year the task is performed, and the success rates that might be achieved.

It must be understood, however, that students completing a plant propagation course in 10 to 16 weeks are in no way highly skilled propagators. These laboratory projects are meant to acquaint them with the art and science of plant propagation, and to give them the knowledge that years of hard work lie ahead to become a highly skilled propagator.

As we do our job of teaching plant propagation, we hope more young men and women are encouraged to become involved in plant propagation as their life's vocation and avocation. There is, of course, no more noble profession!

TEACHING HERBACEOUS PLANT PROPAGATION LABORATORIES

PAUL E. READ

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University of Minnesota
St. Paul, Minnesota 55101

IMPORTANT PRELIMINARY CONSIDERATIONS

In teaching plant propagation laboratories, or for that matter, teaching laboratories of any sort, the objectives of the exercise must be clearly stated. Does the exercise teach a practical propagation technique? Does the exercise teach important priniciples of propagation? It is important that these objectives be clearly stated and that evaluation of the results be assessed in relationship to these objectives at the conclusion of the experiment.

Another important consideration is the students' preparation prior to beginning the exercises in question. It is important that they have adequate opportunity to learn fundamentals of plant science, including plant structure and functions. They should also have a reasonable knowledge of the equipment and materials required for completion of the exercise. These fundamental concepts can be taught through the vehicle of prerequisite courses or through the preliminary parts of the propagation course that precede these exercises.

For any exercise that is to be used, it is important that the instructor test it him/herself. It is important that the exercise

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For any exercise that is to be used, it is important that the instructor test it him/herself. It is important that the exercise

work successfully, and the best way to know that it will work successfully is to have tested the excercise prior to presenting it to the students. This may seem to be an obvious concept, but in the hustle and bustle of the academic world it is easy to overlook such details or to allow oneself to be rushed into a situation of teaching a technique that is not tested prior to giving it to the students. Together with this testing, the instructor must also give strong consideration to careful preparation and planning before the exercise. Just as in a commercial operation, such as a nursery, it is important to plan carefully in teaching. I feel that this is an important concept for students to acquire and one of the best ways to acquire it is to have had it demonstrated by instructors who are well organized. An appropriate approach is to plan a timetable of operations. For many exercises this may mean purchasing plants or growing plants well in advance of the beginning of the semester (quarter). Of course it's also important to order equipment and plant materials with plenty of time allowed for delivery. "Backorder" problems can often cause serious delays in implementing an otherwise well thought out laboratory exercise.

HERBACEOUS PROPAGATION EXERCISES

Special propagation techniques, such as division and separation, are important methods of propagating numerous kinds of herbaceous materials. Such species as iris, peonies, daylilies, dahlias, rhubarb, and cannas are normally propagated by one of these methods. Although relatively simple processes, knowledge of plant structure and where new shoots arise is important. In a species such as dahlia, a knowledge of the necessity for taking a portion of the crown, along with the tuberous root division in which the crown piece includes an "eye" or bud, is important as well. Many of the division and separation techniques and examples are well illustrated in laboratory manuals or textbooks such as those listed in the bibliography for this discussion.

THREE SUCCESSFUL HERBACEOUS LABORATORIES

I will use three successful herbaceous propagation laboratory examples to illustrate different principles and uses that are of a practical nature to the propagator.

Lily Scaling. In this exercise either Easter or garden lily bulbs may be used. This exercise demonstrates organ regeneration adventitiously from modified leaves. It is important to use plump healthy bulbs and to remove any outer scales which are dry, shriveled or damaged. These should be discarded and the next several layers of plump firm scales removed individually. These scales will be placed to approximately one half their length vertically in a moist medium in flats. They may then be placed in a moderate temperature greenhouse (approximately

20°C, or 70°F). A medium which is commonly used for this technique is moist sphaghum peat, but a comparison of media such as vermiculite, peat, perlite, and sand makes this a more interesting exercise if sufficient lily bulbs are available. An alternative procedure is to place the scales in moist (not wet) peat or other medium in polyethylene bags. The medium should only be about half of the volume of the bag and the scale embedded in the medium and the bags securely closed with a twist tie type closure or similar method.

Normally this technique produces tiny bulblets on the cut or broken surface at the base of the scale within three to four weeks time. One beauty of this exercise is that it is predictably successful every time. We have tested this exercise in various ways for 13 years in our laboratories and it has always worked successfully. It should be noted that now, through use of tissue culture techniques, rapid bulblet increase can be achieved much more efficiently than through this method. However, this method is one which can be accomplished with a minimum of equipment by the beginning propagator or the propagator who does not have a tissue culture laboratory facility available.

Potato Tubers from Leaf-Bud Cuttings. This is a method that is of practical use to the potato breeder who wishes to increase a seedling line prior to field planting. A simple procedure, it is necessary to start the potato plants in large pots or containers approximately three months prior to use. This is normally done in a greenhouse. For winter classes in northern latitudes, the growth of these plants can be enhanced by use of high intensity discharge (HID) lamps. The procedure involves removing mallet type leaf-bud cuttings with approximately 2 cm of stem attached to a healthy leaf. The stem length should be equal (1 cm) above the node and below the node. The entire stem segment including the bud is then embedded in the medium to be used. Depth is important and normally, depending on the size of the stem segment, a depth of 2 to 3 cm is recommended. It is important that light be excluded or the bud will grow as a normal axillary shoot rather than forming tiny tubers. Exclusion of light, and possibly oxygen relationships, probably interact with hormones to stimulate tuber formation rather than the shoot that one might expect.

Although moist sand is the recommended medium for this procedure, variations for experiments would include comparison of other media with sand, such as vermiculite, peat, perlite, etc. Another comparison that could be run instead of a medium comparison would be application of growth regulating chemicals such as benzyladenine (BA), gibberellic acid (GA_3), B-nine (Alar, daminozide), or compounds more familiar to the propagator of cuttings such as indolebutyric acid (IBA). Another interesting modification one can incorporate into this experiment is for dif-

ferent students to have different cultivars of potato. Use of unusual cultivars such as 'All Blue' or red skinned types like 'Pontiac' adds color and interest to the experiment. Results will be observed in 3 to 4 weeks.

This exercise also illustrates regeneration of a new structure in an unusual location, or adventitiously. Tiny tubers form in the leaf axil. Usually only one forms at this location but occasionally 2 or even 3 may form. In addition it is common for the cutting to have rooted. The tubers normally reach marble size in this period of time. They can then be broken off from the cutting for planting or storage prior to planting at a later date. Even the smaller tubers (pea size) can be used successfully.

Petunia Leaf Piece Culture. This exercise deals with an extremely simple and nearly always successful tissue culture technique. Since tissue culture is really in many cases just employment of minute or tiny cuttings, some of the principles of propagating by cuttings apply. This exercise demonstrates the influence of hormones (hormone-like growth regulators) on control of root production and shoot production. I particularly like this exercise because it works well and can be done in an open laboratory. It teaches fundamental concepts of asepsis and of hormone effects and interactions.

Procedure involves growing petunia seedlings to the 4th or 5th true leaf stage (or older) and this means starting them one to two months in advance of the exercise depending on the growing facilities and techniques employed. The leaves to be cultured are excised from the stock plants so grown and are surface disinfected in bleach solution (0.5% sodium hypochlorite) for 10 minutes. The leaves are then removed from the disinfecting solution and are rinsed thoroughly in two successive rinses of 5 minutes each in sterile distilled water. They are then transferred carefully into sterile petri dishes and cut into 4 mm wide sections transversing the midrib of the leaf. Instruments for all of these procedures should be surface sterilized, usually by dipping in alcohol and flaming them. The leaf sections are then transferred into sterile petri dishes which have been prepared in advance with modified Lindsmaier-Skoog medium with 0.5 mg/liter benzyladenine (BA), 1.0 mg/liter naphthaleneacetic acid (NAA) or both BA and NAA. The petri dishes are then sealed with parafilm or tape and placed on a lighted laboratory bench or in a growth chamber.

Results are obtained in a relatively short period of time, with some activity visible within 1 to 2 weeks. Small shoots on the BA medium, roots on the NAA medium, and usually callus on the BA plus NAA medium are visible within 3 to 4 weeks. Students can then record their observations and relate the results to principles of hormonal physiology. Ideas for variations to try in this experiment include comparing indoleacetic acid vs. naphthalene-

acetic acid and/or a splitting of the experiment and placing part of the cultures in dark and part in light.

RECAP OF IMPORTANT CONSIDERATIONS

It is imperative that the instructor make sure that the exercise teaches a practice, skill or principle. It is also extremely important that the instructor know that the exercise work successfully The best way to know that, is to have practiced it oneself. Organizing the exercise well in advance of the implementation of the exercise by the students will also enable students to have a successful learning experience from these laboratory exercises. Finally, observations of results should be evaluated and discussed for maximum understanding of the value of these exercises.

Numerous other exercises such as scooping or scoring hyacinths, herbaceous cutting exercises, herbaceous grafting techniques and similar exercises could be handled in a manner similar to the three exercises discussed in this presentation. Such exercises can be developed by the instructor or they can be found in available laboratory manuals.

REFERENCES

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ASPECTS OF A TEACHING PROGRAM FOR PLANT TISSUE CULTURE

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Tissue culturing of plants as a means of asexual propagation is an example of a tool which was developed and refined by the research community long before it gained acceptance as a technology for use in industry. This lack of concomitant development by industry and university researchers has led to communication gaps in the implementation of techniques and applications. Since most plant propagation teaching programs cover tissue culture briefly and from a theoretical perspective, most students are

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unaware of the impact which the emerging tissue culture technology is having and will have on the business of plant propagation.

The Department of Horticulture at Ohio State University has begun a program to address the nursery industry's needs for individuals who have an appreciation for and some knowledge of the techniques of plant tissue culture as a propagation tool. This teaching program encompasses courses taught at several levels. Included in the program are Horticulture 415, the undergraduate plant propagation course, Horticulture 715, a graduate level course in techniques and applications of tissue culture, and, Horticulture 293, 593, and 993, which are undergraduate or graduate level and are taught as individual studies with special permission of the program coordinator.

Students in the plant propagation course, Horticulture 415, are exposed to only the basics of plant tissue culture. Since both lecture and laboratory time are extremely limited, a student could not be expected to do tissue culturing independently after only such a brief exposure to the methodology. Furthermore, the objective of teaching tissue culture as a part of the plant propagation course is to familiarize the student with the concept of tissue culture as a propagation tool rather than the specifics of the methods.

The fundamental principles which are emphasized in the teaching program at this level are extremely basic (Figs. 1-4). Factors to be considered when choosing a tissue source for the original explant are covered (Fig. 1). Anatomical and morphological changes accompanying the proliferation of multiple shoots from leaf tissue (Fig. 2) and from shoot tip explants (Fig. 3) are explained with liberal use of visual aids including actual cultured specimens. Perhaps the most attention is given to the presentation of the concept of subculturing (Fig. 4) since it is through this process that the extraordinarily high multiplication rates characteristic of tissue culture methods are achieved. To complete the teaching of the propagation cycle, methods for rooting of the cultured plantlets and the procedures used to acclimate the plantlets to the greenhouse environment are presented.

Conspicuous by its absence from the undergraduate program in tissue culture is an indepth discussion of tissue culture media and the role of hormonal regulation in shoot proliferation. The underlying premise behind this course organization is that students are inadequately prepared at this level to understand the intricacies of media formulation and that a brief mention of the roles of cytokinins and auxins is sufficient for them to grasp the concepts of regulation of differentiation. The essentiality for sterile technique, however, is very vividly demonstrated in the laboratory, where almost every student has a personal encounter with

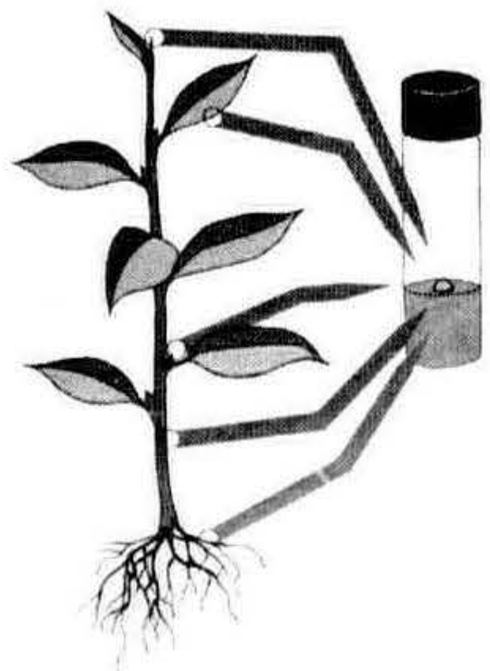

Figure 1. Explants for tissue culture may be obtained from shoot tip, leaf, lateral bud, stem or root tissue.

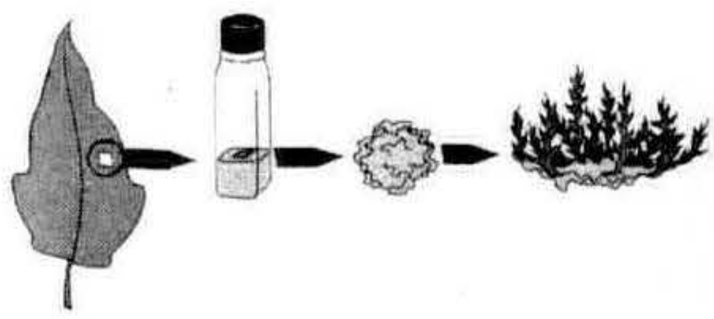

Figure 2. Leaf tissue explants of some species produce callus and then undergo shoot proliferation when placed in the tissue culture environment.

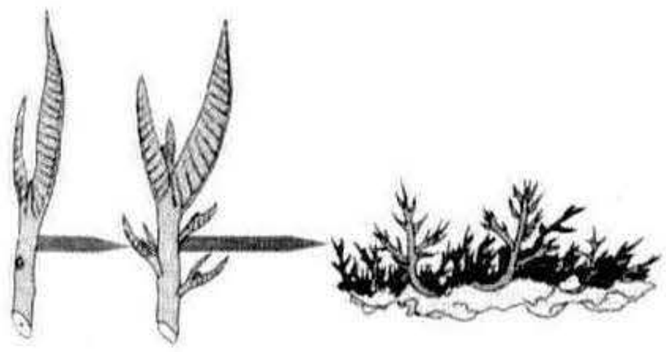

Figure 3. A shoot tip explant placed in tissue culture often multiplies by continuous growth of axillary shoots when apical dominance is overcome in tissue culture.

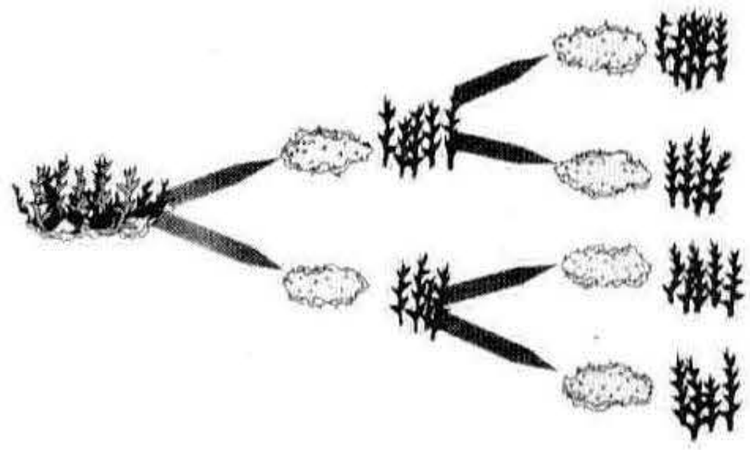

Figure 4. The ability to successively harvest shoot tips for rooting and increase the number of cultures by subculturing emphasizes the tremendous potential for mass propagation through tissue culture.

media contamination on a portion of his experiment.

The lecture portion of the tissue culture presentation in the plant propagation course is reinforced by allowing students "hands-on" experience in the laboratory. Students select an explant source, sterilize and rinse their tissue, and place the tissue on three different media. Greenhouse grown herbaceous material as well as woody trees and shrubs growing outdoors which are in a growth state favorable for tissue culture are all used as starting material. This diversity of plant species as well as the three media types allows for excellent and dramatic comparisons of tissue development in culture.

The undergraduate course in plant propagation at Ohio State University and at many other universities provides a good introduction to tissue culture technology. However, these students cannot be expected to fulfill the industry's need for tissue culture technicians or managers without a considerable amount of further educational or on-the-job experience.

Graduate level training and advanced individual studies (Horticulture 715, 293, 593, 993) provide students with more of the fundamental experience and knowledge required of tissue culture technicians and laboratory managers. Included in their flexible and individually designed programs are courses in the basic plant sciences, plant pathology, microbiology, and organic chemistry (Fig. 5). Additionally, graduate level courses should emphasize the "science" of tissue culture itself, including plant morphogenic responses and chemical control of growth and differentiation *in vitro*. Through their own research programs, students not only learn the detailed responses of the species with which they are working but, more importantly, they learn how to take a scientific approach to problem solving and research on any species.

Complete mention of the specific topics which are covered in the advanced tissue culture courses is beyond the scope of this essay. Several of the fundamentals are discussed. The first fundamental for introducing a species into culture is obtaining sterile explants. Emphasis is placed upon taking actively growing tissues, preferably from a greenhouse grown source. Students are taught simplified procedures for media preparation and storage. The importance of conducting experiments to test the effects of auxin and cytokinin interactions on the path of culture differentiation is demonstrated. Research applications other than mass propagation are stressed in Horticulture 715, including the techniques of cellular selection, protoplast isolation and culture, somatic hybridization, and meristem culture to obtain disease and virus-free stock.

Experience in evaluating the retention of knowledge by individuals after exposure to the teaching program in tissue culture at

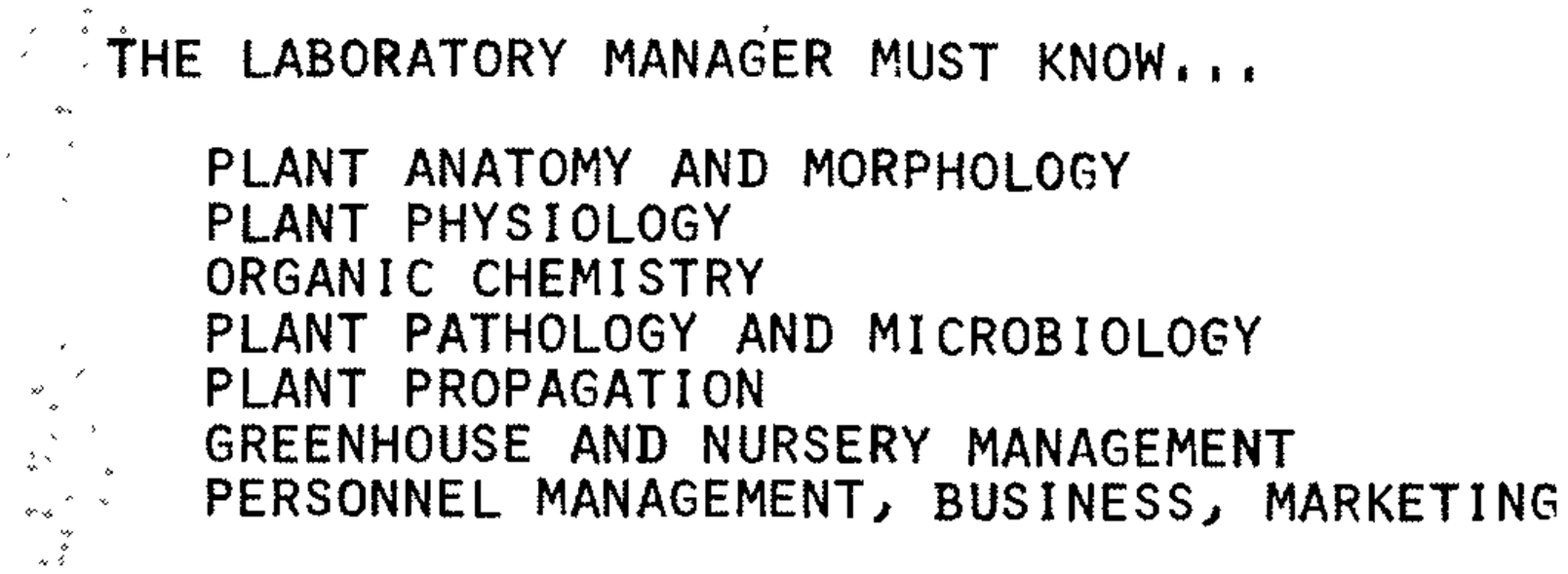

Figure 5. The manager of a tissue culture laboratory must have sound fundamental training in the physical, chemical, and plant sciences

the different levels has led to the following summaries The plant propagation student, after only an abbreviated introduction to tissue culture technology, has grasped the concept of mass propagation but cannot effectively function in the commercial laboratory without on-the-job training. This evaluation may come as no surprise to the members of the industry since they tend to view most college graduates as deficient in practical knowledge of all phases of plant propagation. The commercial tissue culture laboratory must seek a person with advanced training in tissue culture for supervisory and management positions. These individuals may be weak in the areas of business and management, but should have an excellent grasp of the basics of tissue culture technology.

As a final summary, some reiteration should be made of a concept mentioned in introducing this essay. A communication gap between industry and academia resulted in delays in the commercial implementation of tissue culture technology. Unless more efficient communication between the groups in fostered, this gap will also be reflected in the teaching programs in tissue culture and plant propagation.

SEED PROPAGATION LABORATORIES AT PENN STATE UNIVERSITY

CHIKO HARAMAKI AND DAVID BEATTIE
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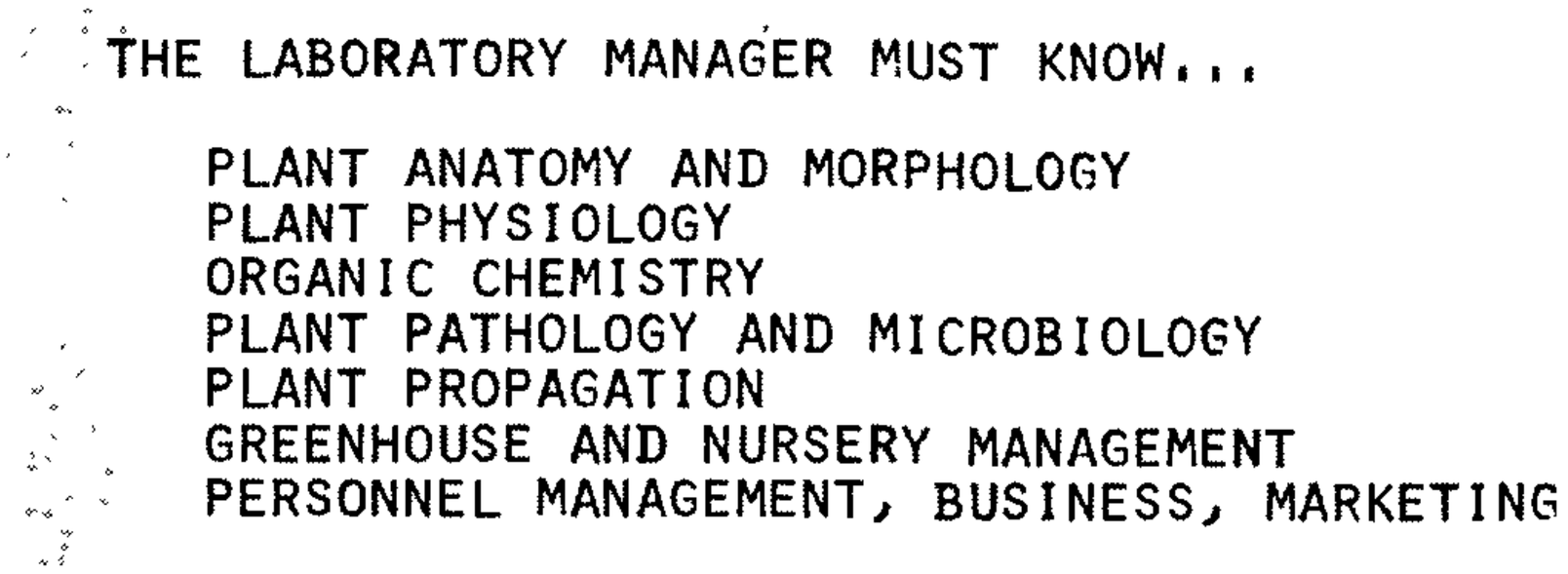
At The Pennsylvania State University there are three plant propagation courses, each at a different level. The first one is for our two year diploma students and it emphasizes the practical



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with some theory. The course for the four year baccalaureate students stresses the principles as well as the practices. the graduate level course is primarily theoretical in which reports are give on specific topics and is followed by discussion.

Students who take these courses are primarily horticulture students but others come from agricultural education, forestry, plant pathology, agronomy, and other plant sciences as well as students who are just interested in the propagation of plants.

The main objectives of the baccalaureate course are to develop an understanding of the basic principles of plant propagation, to develop the ability to propagate plants, to develop the ability to evaluate experiemental results and to determine and apply these techniques. Another important aspect is to encourage their communications skills by requiring extensive reporting of experimental results and to require a formal term report.

Before each laboratory an outline which lists the title, purpose, materials, methods and references is given to the students which explains what they are going to do, how to do it, and what is expected to occur. The students turn in written laboratory reports after completing the exercises. We feel that this is an important aspect of their education. They learn how to make observations and then discuss why they got the results they did, even if in some cases the results may be contrary to what was expected. The students are expected to use the trade and scientific journals, monographs and books to back up their discussion and conclusion. Since most students do not write enough, another important aspect of the laboratory reports is that they learn how to write a logical and concise report.

One of the seed exercises involves the effects of light and chemicals on the internal dormancy of selected seeds. Chemical treatments include GA_3 - 100 ppm, thiourea - 1,000 ppm, KNO_3 - 10,000 ppm, and a control. One replication is placed under 16 hours of light per day and a duplicate set under 24 hours of darkness. The students observe that some seeds germinate under certain chemical and light conditions while others do not. The effects of treatments on subsequent seedling growth after germination are also observed.

Another exercise involves germinating hard coated seeds such as honey-locust, Kentucky coffetree and redbud. The various treatments include placing the seeds in concentrated sulfuric acid for 15, 30, 45, 60 and 90 minutes as well as having a control sample. The instructor sets up parallel experiment in which the seeds are treated with concentrated sulfuric acid for 2, 3, 4, 5, 6, 7 and 8 hours. The students observe the germination rate and percentages as well as the effect of inhibiting seedcoat remnants and any damage which may occur to the embryos.

A comparison of several standard seed viability tests such as rolled paper towel, blotter and soil tests are made to determine the ease and reliability of these tests. These are compared with chemical tests using the same seeds. Seeds are soaked in 0.004% malachite green and the live tissue turns the green stain into colorless leucomalachite while the dead tissues remains green. Other seeds when placed in a colorless 0.25% solution of 2,3,5-triphenyltetrazolium chloride soon turn red in the viable, respiring areas. The chemical is reduced to an insoluble red dye called triphenyl formazan. In dead tissues there is no color change.

Seeding laboratories also occur in other horticultural courses such as nursery production and management where the students determine the seed storage and after-ripening requirments, prepare the seed bed, fumigate the soil, sow and later transplanting the seedlings. In the plant breeding courses students make their own crosses, determine the germination requirements for these seeds and grow these seedlings. In floriculture production courses students may select a seed-grown crop for their project, find out the germination requirements as well as the culture, and then grow the crop.

What we are trying to do in our seed laboratories is to teach the students the principles of seed germination and familiarize them with the various sources of information so that they can prepare schedules for pretreatments and sowing in order to get the required number of normal seedlings when they are needed.

Friday Morning, December 12, 1980

Dr. Leonard R. Stoltz served as moderator of the morning session.

GRAFTING — HOW, WHY, WHEN

GERALD VERKADE

R-13 Lower Boulevard
New London, Connecticut 06320

Today, I would like to talk about "out of the ordinary" grafting techniques. The first technique, grafting a scion onto a root piece, can be used with a plant when you do not have a suitable understock and the plant is difficult to root. We have used this technique with *Sciadopitys verticillata*. Long root pieces are cut into sections and the scion is grafted to a root piece utilizing a side veneer graft. The grafting operation is conducted

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at the same time when you would root the cuttings in February-March. We have achieved a 90% success rate with this method. With *Sciadopitys verticillata* we have noticed that the scion is often rooted after one growing season. This is often called, "nurse-root grafting"

Every so often in an organization like ours we make a mistake. Instead of having some potted understock ready for grafting we find ourselves ready to graft and lacking understock. We have found with red, Scotch, Austrian and white pines that understock can be fresh dug and immediately grafted. In some cases the understocks have literally been chopped out of ice. The understock is grafted bareroot with a side veneer graft and placed in peat. After union formation, the rootstock is pruned back and the grafts are potted up.

The third grafting type, "cutting-grafting", is useful with new clones that are difficult to root. We have used this technique on rhododendrons. Cuttings of an easy to root cultivar, such as R. 'Roseum Elegans', are made and the scion is then attached with a side veneer graft After tying, the easy-to-root cultivar is treated with hormone and stuck in the bench under a polytent. When the cuttings are rooted and graft union formation has occurred the understock is cut back and the grafts are potted up.

The last grafting technique, single-node grafting, is useful when you have a shortage of grafting material. We have used this technique with Japanese maples. In single node grafting a small scion piece, about one inch in length, is grafted to the rootstock. To show you the stock buildup potential of this method, we were able to take one Japanese maple cultivar in 4 years to 20,000 plants

THE EFFECT OF GIBBERELLIC ACID AND BENZYLADENINE IN INDUCING BUD BREAK AND OVERWINTERING OF ROOTED SOFTWOOD CUTTINGS

JAMES F. McCONNELL[1] and DALE E. HERMAN[2]

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Shenandoah, Iowa 51601
[2]*Department of Horticulture*
North Dakota State University
Fargo, North Dakota 58105

Abstract. Gibberellic acid (GA_3) and a cytokinin, N-6-benzyladenine (BA) were applied to softwood cuttings of *Salix pentandra* L (laurel willow) and *Viburnum lantana* L (wayfaring tree) in an attempt to promote shoot growth and

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subsequently increase overwinter survival of the cuttings through a buildup of photosynthetic carbohydrate reserves Gibberellic acid caused fewer but signifcantly longer shoots on laurel willow while reducing overwinter survival Wayfaring tree reacted to GA_3 treatment by an increase in the number of bud breaks, no increase in shoot length and reduced overwintering ability. Benzyladenine stimulated bud initiation on laurel willow, reduced average shoot length, and increased overwinter survival Benzyladenine had little measurable effect on wayfaring tree other than slightly increasing overwinter survival

INTRODUCTION

Poor overwinter survival rates of rooted softwood cuttings from woody plants is a perplexing problem. The rooting process results in a drain of photosynthetic food reserves from a cutting, leaving it in a depleted nutritional state to overwinter and break dormancy the following spring. Cuttings of such genera as *Acer*, *Berberis*, *Betula*, *Cornus*, *Viburnum*, and cuttings of many other genera, when rooted late in the growing season, serve to illustrate the magnitude of this propagation problem.

It is commonly observed that cuttings which can be induced to initiate new shoot growth the same season in which they are rooted, survive overwinter better than those which have not initiated new growth. Even small amounts of growth will improve overwintering ability of a rooted cutting due to the manufacture of reserve carbohydrates. Thus, treatments that encourage new growth and carbohydrate replenishment before the onset of dormancy would be expected to improve overwinter survival percentages. Of the hormonal growth regulators available today, two classes have shown an effect on breaking the dormancy of buds and inducing growth. Those classes of regulators are the gibberellins and cytokinins.

With varying degrees of success, gibberellic acid has been used to stimulate shoot growth on a wide variety of plant materials. It has been found that gibberellic acid can at least partially overcome the rest period of buds, a process normally accomplished by prolonged chilling. By overcoming the physiological rest of a bud, new growth commences and photosynthetic nourishment can begin. It has been noted, however, that GA leads to the expansion of the apical buds while inhibiting lateral bud development. A study by Loach and Whalley (9) on the effects of gibberellic acid on rooted cuttings of *Betula pendula*, however, showed that GA promoted irregular bud breaks, produced weak growth and only marginally improved overwinter survival. Similar results were also observed in cuttings of certain species of *Berberis*, *Acer*, *Cornus* and *Weigela*, where only weak and etiolated growth was found after GA application. Furthermore it has been speculated that exogenous applications of gibberellic acid are partially responsible for the inhibition of lateral shoot development (7).

Cytokinins induce growth of dormant buds by overcoming the inhibitory influence of auxin and by the induction of cell division. Experimentally, cytokinins have been used successfully to overcome apical dominance in axillary buds of Japanese holly (6,11), apple shoots (1,7), pines (3,4), roses (2,10) and numerous herbaceous plants. Cytokinins have also been analyzed for use in overcoming the rest period of such deciduous woody plants as apple (12), birch and poplar (5). It is commonly observed that the number of shoots developing on a stem increase with the application of a cytokinin; however, a reduction in growth rate of those stimulated shoots also occurs.

The intent of this experiment was to study the effects of gibberellic acid (GA_3) and benzyladenine (BA) in stimulating new growth and subsequent overwintering ability on rooted cuttings of *Salix pentandra* L. and *Viburnum lantana* L.

METHODS AND MATERIALS

Softwood terminal cuttings of *Salix pentandra* L. and *Viburnum lantana* L. were cut approximately six inches long. The basal ends of half the cuttings were treated with indolebutyric acid (IBA) at 5000 ppm while the other half remained untreated. The cuttings were placed in six compartmented cell-packs containing 50% peat:50% perlite and immediately set into intermittent mist propagation beds.

Gibberellic acid was applied as both a spray and as a direct bud application at two concentrations: 1000 and 4000 ppm to equal numbers of cuttings of both plant species. Benzyladenine at 200 and 1000 ppm was applied in an identical manner to another group of cuttings. To determine if timing of application of the hormones was critical, certain cuttings were given GA_3 and BA treatments immediately after being placed into the rooting medium. Others were treated two weeks after being placed in the rooting medium and a third group was given three applications of hormones starting two weeks after being stuck and at two week intervals thereafter. The application timing trials involved equal numbers of cuttings as well as an equal group of untreated controls which were used for comparison purposes.

The data collected on laurel willow was taken in late fall after dormancy had been initiated and consisted of the number of dormant buds breaking dormancy and shoot length. The data collected on wayfaring tree included simply the total number of buds breaking dormancy. Overwinter survival data were collected on both species in early spring as the cuttings began to grow. The overwinter survival data reflects the percentage of survival of the original number of cuttings stuck.

Cuttings were overwintered in a lath shade structure. The cell-packs containing the cuttings were covered with ¼″ micro-

foam insulation blankets and an additional layer of 6 mil white polyethylene plastic.

A completely randomized factorial design was used to test the effect of the hormonal treatments. Analysis of variance procedures were used to test data for significance and Duncan's Multiple Range Test was used to identify significant differences in mean values at the 5% level.

RESULTS AND DISCUSSION

Laurel willow. The effects of the rooting hormone IBA were difficult to assess on laurel willow since this species readily produces a prolific root system. Unpublished data reveals that the shoot inducing hormones, GA_3 and BA, when applied to laurel willow cuttings treated with IBA, resulted in very minimal interactions such as enhancing or depressing shoot length, number of buds breaking dormancy or overwinter survival.

Statistically significant difference in average shoot lengths are noted between those cuttings that were treated with gibberellic acid and those treated with benzyladenine (Table 1)

Table 1. Effect of gibberellic acid and benzyladenine treatments on average shoot length, mean number of shoots and percent overwinter survival of laurel willow

	Year 1			Year 2		
Treatment (ppm)	Ave shoot length (cm)	Mean No shoots	Percent over-wintering	Ave shoot length (cm)	Mean No shoots	Percent over-wintering
GA_3 1000	4 4[a]	62[b]	37 0[b]	9 2[a]	90[bc]	95 8
GA_3 4000	5 6[a]	53[b]	19 9[c]	8 8[a]	81[c]	96 8
BA 200	1 8[b]	91[a]	59 1[a]	6 3[b]	1 02[b]	96 8
BA 1000	1 7[b]	96[a]	56 0[a]	6 0[b]	1 21[a]	98 6
Control	2 1[b]	1 02[a]	52 8[a]	6 5[b]	95[b]	98 4

(Data based on 216 cuttings per treatment)
Note Means with the same letter are not significantly different at the 5% level

Gibberellic acid caused a marked increase in shoot length of treated cuttings while reducing the number of shoots produced by those cuttings. Gibberellic acid may be involved in mobilizing the plant's nutrients to a single shoot whereupon the newly developing shoot takes over apical dominance and supresses the growth of other buds. A harsh first year winter revealed a significant reduction in overwintering ability of those GA_3-treated cuttings. It is quite possible that GA_3 causes the plant tissues of laurel willow to remain in a more succulent state and freezing temperatures could cause tissue damage.

The benzyladenine treatments on laurel willow caused an increase in the number of shoots produced per cutting while slightly reducing the length of each shoot (Table 1). If a larger number of shoots form on a single cutting, competition for nutrients would logically reduce the size each can attain.

Two methods of applying the shoot inducing hormones, BA and GA_3, were tested. Spraying as a means of application proved to be equally as effective as direct bud application. The direct bud application method proved to be time consuming and laborious and for this reason the spray method is recommened as the simplest method of treatment.

Timing, as well as number of applications of gibberellic acid and benzyladenine, were varied to determine the most appropriate sequence to follow when treating cuttings for stimulation of bud break. Statistically significant results were not obtained from this analysis; however, repeated applications of the hormones caused the greatest increases in the number of bud breaks. Repeated applications were begun two weeks after the cuttings were placed in the rooting medium. The two week delay was intended to allow at least partial rooting to begin. The rooting process should be at least partially completed prior to bud break since both processes compete for the available food reserves in the cutting.

Wayfaring tree. Indolebutyric acid somewhat aided the rooting of wayfaring tree. As in the case of laurel willow, however, the interactions between IBA and the shoot inducing hormones, BA and GA_3, were not significant.

Gibberellic acid was found to significantly promote more bud breaks of wayfaring tree than either the untreated controls or benzyladenine treatment (Table 2). Shoot lengths were not recorded since extension growth on buds breaking dormancy were too short to be measured in a practical manner. Gibberellic acid significantly reduced the percent overwinter survival of wayfaring tree the second year.

Table 2. Effect of gibberellic acid and benzyladenine treatments on mean number of bud breaks per cutting and percent overwinter survival of wayfaring tree

Treatment (ppm)	Year 1		Year 2	
	Mean No bud breaks	Percent overwintering	Mean No bud breaks	Percent overwintering
GA_3 1000	0 08[a]	29.9[b]	0 63[a]	85 2[bc]
GA_3 4000	0.14[a]	29 9[b]	0 51[a]	81 0[c]
BA 200	0 08[a]	38 8[a]	0 32[b]	89 4[ab]
BA 1000	0 05[b]	39 3[a]	0.26[b]	87 5[abc]
Control	0 05[b]	24 5[b]	0 31[b]	93 1[a]

(Data based on 216 cuttings per treatment)

Note Means with the same letter are not significantly different from each other at the 5% level

Benzyladenine showed very little effect on wayfaring tree. Only in the first year of experimentation did BA at 200 ppm

produce significantly more bud breaks than the untreated controls. During that same year the overwinter survival due to BA treatment was significantly increased as well. A possible explanation of this result might be that BA, as is characteristic of cytokinins in general, mobilizes nutrients and may offer some protection against nutrient leaching and cutting degradation.

CONCLUSIONS

Little research has been done to improve the overwinter survival of newly rooted cuttings of woody plants, which often have a high mortality rate during or immediately after their first dormant period Stimulation of growth of the cuttings is a logical practice since building up carbohydrate reserves should enhance overwinter survival The use of gibberellic acid and benzyladenine have proven to be partially effective in achieving shoot growth of rooted cuttings A suggested treatment to be researched in the future is to use the two hormones in combination. A synergistic response could result in increased numbers of shoots with sufficient extension growth to provide larger leaf area. If larger leaf areas can be produced, more photosynthetic products will be manufactured and stored. Another possible alternative could be the use of hormonal combinations plus supplemental artificial light to extend the photoperiod during and after the rooting process. Long days promote vegetative growth and in some cases have been shown to enhance the rooting process as well.

The overwinter survival of rooted cuttings is dependent on many factors, not the least of which is the stored nutrient status of the cutting prior to the onset of dormancy. The applicaiton of gibberellic acid and/or benzyladenine to promote shoot growth and thereby increase food reserves may become a practical nursery practice but further work is needed to determine optimal times, rates of application, and effectiveness on each species to be treated If higher overwinter survival rates can be obtained through the use of applied hormones plus extended photoperiods, this will definitely be of great economic significance to the nursery industry.

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CLAYTON CARL: Did I understand you correctly when you said that you treated the cuttings before sticking in the propagation medium?

JAMES McCONNELL: Yes. We did use a sticker and did allow the cuttings to dry before placing them under the mist.

CLAYTON CARL: We have been using GA_3 on sugar maple cuttings but after coming out of the propagation bench.

JAMES McCONNELL: That is what we were trying with the repeated applications. We still had 1 or 2 more treatments after the cuttings came out of the propagation bench.

CAMERON SMITH: Would you like to speculate on the use of these chemicals to produce lower branching on plants such as columnar buckthorn?

JAMES McCONNELL: I can only speculate. Some research has been conducted in this area. For example, 'Crimson Pygmy' barberry often produces a spindly plant but treatment with benzyladenine has increased branching and made a more saleable plant.

PROPAGATING PINK DOGWOODS FROM ROOTED CUTTINGS

LEONARD SAVELLA

Bald Hill Nurseries, Inc.
Exeter, Rhode Island 02822

One of the finest ornamental trees available to us for landscaping is the dogwood. The dogwood with its large flowers in the spring, glossy green foliage in the summer, bright red berries and spectacular color changes of the foliage in the fall, and interesting horizontal branch formations for the winter make this small tree enhancing to most every landscape. In my opinion there is no other ornamental tree that can equal this year round beauty.

Propagation of the shrub forms and some tree forms of the genus *Cornus* is easily done by seed, layering, and cuttings. However, cultivars of the species, *Cornus florida*, are more difficult. Cultivars of *C. florida* until now, have been propagated mostly by grafting and budding with some success by cuttings.

This paper today will be on propagating the cultivar *C. florida* 'Rubra' commercially from rooted cuttings.

Before any cuttings are taken in June and July the propagation medium is prepared by mixing perlite and peat (60:40), and wetting until it is thoroughly moist. The medium is then leveled off in the bed to 6″ and pressed firmly with a board similar to a mason's trowel. This is important because a loose medium will give poor results.

Once the bench is prepared the workers gather the cuttings by taking 6 to 8″ of new growth and placing them in a poly bag to prevent desiccation. In the workshop the cuttings are spread on the concrete floor and covered with wet burlap. This procedure must be done in as short a time as possible to prevent wilting of the soft cuttings.

The cuttings are next brought to the work bench 2 or 3 bushels at a time where they are stripped of all leaves except the last two pair at the top of the cutting. The remaining leaves are then cut in half [cutting the leaves allows you to get more plants in the bed; do not overcrowd]. The cuttings are trimmed to about 6 to 7″ long. Wounding is not necessary.

The cuttings are dipped into Hormodin No. 2 powder, pegged into the medium, watered in, and automatically misted from then on. For those who do not have an automatic mist control a 5 second mist every 6 minutes is a good setting on your time clock.

In 6 to 8 weeks, the cuttings should be rooted. They are now removed from the propagating bench, potted in 2¼″ clay pots

using the same mixture of perlite and peat as a potting mix and placed back under mist. This is very important. The reason for placing them back under mist is to get some new root growth in the pot Once you have obtained new root growth, no matter how little, shut off the mist and allow the rooted cutting to go dormant.

After the plants have become dormant they are placed side by side in a pit house (6′ in the ground). Sand is spread over the tops of the pots then washed in so that the pots are covered to a depth of ½″ above the top. The pit house is unheated and in colder areas it may be a good idea to loosely cover the cuttings with 4″ of marsh hay. On days when the winter temperature is above freezing the pit house is aired for one hour or more and the pots are checked to see if they need watering. I would say that not more than 2 waterings per winter are necessary unless you have very dry conditions. You are better off to have them a little on the dry side. Frost will occasionally occur on very cold nights to a depth of ¼″ in the sand which does not seem to be harmful to the cuttings. I believe this dormant period with a slight frost is most important if the cuttings are to break in the spring.

The cuttings are left in the pit house until June. By this time new growth has started. At this time they are planted outdoors in soil beds 6 to 8″ apart. After planting they are watered, treated with Ronstar herbicide, mulched with shredded bark, and covered with 50% lath shade.

The shade is kept over the plants until the following summer and then removed. After one growing season in the bed the dogwood should grow to a height of 2½/3′, and 3/4½′ if they are kept in the beds for two years.

JOE CESARINI: Have you tried rooting hardwood cuttings?

LEN SAVELLA: No. Why should we when they root so easily as softwood cuttings?

JOE CESARINI: Because hardwood cuttings are much cheaper to produce than any other type of cutting.

VOICE: What is your percent rootings?

LEN SAVELLA: 100%.

MARY BARDOL: Do you remove the terminal bud?

LEN SAVELLA: No.

JIM SINGER: What was the hormone you used?

LEN SAVELLA: Hormodin No. 2.

ELWIN ORTON: A number of people feel that rooted cuttings of *Cornus florida* 'Rubra' are unusually susceptible to winter injury for a number of years after transplanting out into the

field. What has your experience been?

LEN SAVELLA: We have been growing pink dogwoods this way for 18 years and have never had any problems

PETER VERMEULEN: I notice you are using clay pots and not plastic. Do you have any comments?

LEN SAVELLA: I find that if I put them in plastic pots they dry out faster. They stay wetter in clay pots under the sand and need only 1 or 2 waterings during the winter.

MICHAEL DIRR: Have you tried *Cornus kousa*?

LEN SAVELLA: Yes They work equally well under this same conditions.

PROPAGATION AND GROWTH OF FRASER FIR

JAMES S. COARTNEY AND ROBERT WRIGHT
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Blacksburg, Virginia 24061

Fraser fir (*Abies fraseri*) is a handsome forest tree localized to high elevations (>4000 ft.) of Virginia, West Virginia, Tennessee, and North Carolina. Its name was given in honor of Fraser who introduced it into England in 1811. The Fraser fir is very closely related to the balsam fir. (*A. balsamea*) and probably originated as a relic community of the balsam fir following glacial retreat (1)

The differences between the balsam fir and the Fraser fir are subtle. The botanical separation is based primarily upon differences in the cone structure Under close observation the Fraser fir appears to have greater needle density, better color, and more wax on the buds and leaves. It is these qualities that make it a highly prized Christmas tree species. The Fraser fir also begins growth later in the spring which makes it less likely to be injured by frost. These attributes make Fraser fir a highly prized Christmas tree species which will command higher prices than good quality pine or spruce. The annual harvest of Fraser fir Christmas trees now exceeds $10,000,000. Demand for the trees greatly exceeds the supply and there is much interest in increased production in North Carolina, and Virginia.

The hindrance to increased Fraser fir Christmas tree production is the lack of planting stock. Seedling growth is slow and 5 years are usually required to produce a suitable field transplant. There is insufficient information on the proper methods for seed-

field. What has your experience been?

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The hindrance to increased Fraser fir Christmas tree production is the lack of planting stock. Seedling growth is slow and 5 years are usually required to produce a suitable field transplant. There is insufficient information on the proper methods for seed-

ling production. Some growers are now successfully producing seedlings but still have only partial knowledge of precise growth requirements.

The increased demand for planting stock has also created a shortage of seed. The native stands in Virginia and North Carolina have been the primary source of seed. Much of this area has now been purchased by the Department of Interior for preservation as a "wilderness" area, which prevents further seed collection. However, through the group efforts of a Fraser Fir Advisory Committee composed of representatives from the Virginia and North Carolina Cooperative Extension Services, Divisions of Forestry and Christmas Tree Growers Associations, plans are being formulated to allow limited seed collection from the Federally owned land. These efforts should supply the short term need for seed.

The long term solution to the seed availability problem is to establish a Fraser fir seed production area. Through the efforts of the Advisory Committee and funding by the Tennessee Valley Authority a seed production area is being established. The first stage was completed in the spring of 1980 when 200 select trees from grower plantations were moved to a desirable site in the Grayson Highlands State Park, Grayson County, Va. This area is located within the confines of the native Fraser fir stands. Additional trees will be moved from "wilderness" areas in 1981. The trees moved to the site are in the 4 to 5′ range and it is expected that it will be 10 to 15 years before significant quantities of seed can be produced.

In view of the limitations set by the current seed supply, it is essential that efforts be made to maximize the harvest of seedlings from a given seed lot. There is also need to research ways of reducing the 5 years required to produce seedlings and to explore alternative methods of planting stock production. North Carolina researchers are engaged in a major research program to study various Fraser fir problems. Virginia research efforts are on a more modest scale and basically cover 3 areas: a) to determine if Fraser fir would respond to accelerated growth techniques; b) to study the effect of shading, soil modification, and fertility on transplant production; and c) to survey field production sites in Virginia to determine if tree vigor could be correlated with elevation, exposure, soil type, organic matter, or soil fertility.

The first phase was accomplished using accelerated growth techniques patterned after those used by Michigan State researchers and discussed by John Hart of Michigan State before this group last year (2,3). Seedling plants germinated in September were grown in the greenhouse until February. At this time the small dormant plants were placed in a lighted growth chamber at 46°F. Plants were removed from the growth chamber after

2, 4, 6, and 8 weeks and transfered to the greenhouse for observation. Following 4 or more weeks of cold treatment the buds broke dormancy and produced another flush of growth. The amount of ensuing growth was related to fertility level before the chilling began. A maximum response was obtained when the plants were supplied with 400 ppm of N in the NH_4NO_3 form. Although not part of this experiment, a separate group of 2 year old seedlings held in the dark at 40° for 6 weeks also broke dormancy and produced a normal flush of growth when field planted.

The second phase dealing with transplant production in field beds was initiated in 1980 and will not be evaluated until 1981.

The third phase dealt with the evaluation of 41 plantings of Fraser fir in a 6 county area of southwest Virginia to determine what constitutes a good planting site. Collection data included elevation, exposure, soil type, orgnaic matter, pH, CaO, MgO, P_2O_5, and K_2O. This survey revealed good growth of Fraser fir plantings at elevations ranging from 1500 to 4000 ft. at pH levels ranging from 4.6 to 6.5 at organic matter contents ranging from 1.5 to 10.3% and at Ca, Mg, P, and K levels ranging from low to high. These results still do not allow us to define the requirements of a site which provides good growth potential for Fraser fir. It seems that a combination of factors are involved. Elevation and soil type are probably the prime considerations. At lower elevations, soil requirements probably become more exacting.

Conclusions: The Fraser fir has great potential for increased Christmas tree production if planting stock can be supplied. Fraser fir lends itself to accelerated growth techniques. There is considerable need for information on alternated methods of propagation such as rooting of cuttings, tissue culture, etc.

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HYDRANGEA ANOMALA SUBSP. PETIOLARIS AND ITS PROPAGATION

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Hydrangea anomala subsp. *petiolaris* is a large climbing plant native to Japan and China. In its native habitat it often attaches to trees and can ascend 80 ft to the treetops. Attachment is by rootlike holdfasts which are stimulated to develop when the new shoots touch objects offering surfaces on which they might climb.

In cultivation *H. anomala* subsp. *petiolaris* has a number of landscape applications. Among these are the ability to grow over boulders, stone walls, posts of any height or on tall trees. When grown on the walls of buildings the plants can cover large areas and provide spectacular displays when in flower. An 88 year old plant of *H. anomala* subsp. *petiolaris* growing on a northeast wall of Arnold Arboretum covers about 500 square feet and has trunks 8 inches in diameter 3 feet above the ground. A 60 year old specimen which has climbed 3½ stories on a stucco wall is depicted in figure 1. When bare of leaves and when contrasted against the light colored wall it is bizarre. An excellent example of a tree grown specimen could be seen at the Arnold Arboretum for many years (Fig. 2). The host, an American elm, succumbed to Dutch elm disease The hydrangea with no object on which to climb now sprawls around on the ground.

Hydrangea anomala subsp. *petiolaris*, hardy enough to be grown in regions comparable to the warmer parts of Vermont, is free of insects and diseases. In nature it is an understory plant and, therefore, adapted to grow in relatively low light. However, it flowers more freely when provided with some sun.

FLOWERING AND FRUITING CHARACTERISTICS

The flower clusters of *H. anomala* subsp. *petiolaris* develop at the terminal ends of lateral branches which grow horizontally from the main trunks They consist of conspicuous sterile flowers and numerous small fertile ones. A floral structure such as this is known as an inflorescence The showy sterile flowers are, no doubt, display adaptations designed to attract pollinating insects.

The fruits of *H. anomala* subsp. *petiolaris* consist of capsules containing prodigious numbers of minute, winged seeds. In autumn when capsules open in preparation for seed dispersal they remain vertical and open only at their tops. This design prevents spilling of tiny, winged seeds yet allows winds to enter the capsules and carry them away from the mother plant. During

Figure 1. Contrasted against a light colored stucco wall, this 60 year old, 3½ story tall *Hydrangea anomala petiolaris* is bizarre.

Figure 2. A tree-grown *Hydrangea anomala* subsp. *petiolaris* at the height of its floral display. (Photo by Arnold Arboretum)

winter, the supporting stem of the inflorescence weakens and breaks away allowing the unit to fall from the plant.

PROPAGATION BY SEEDS

Most very small seeds usually do not benefit from pretreatment by cold — *H. anomala* subsp. *petiolaris*, however, is an exception. Germination is increased and unified if the seeds are subjected to a cold treatment. This can be accomplished by sowing the seeds in flats, or other containers and placing them out-of-doors for the winter in a sheltered location such as a cold frame. An alternate method of stratification would be to put the containers of sown seed in a polythylene plastic bag which is bound at the mouth with a rubber band to make it vapor proof. The cold requirement is then satisfied by putting the bag in a refrigerator set at about 40°F for about 2 to 3 months.

PROPAGATION BY CUTTINGS

Most taxa of *Hydrangea* are among the easiest of plants to propagate by softwood cuttings. *H. anomala* subsp. *petiolaris*, however, is an exception. It behaves in a highly unusual manner. Ordinarily when softwood cuttings are prepared, basal cuts are made just below nodes and roots arise in that area. Roots on cuttings of *H. anomala* subsp. *petiolaris*, however, may or may not appear at that location. On some, the roots that would normally serve as holdfasts become functioning roots. They develop between the nodes (Fig 3). Other cuttings root only at their bases (Fig 4) while on still others, rooting is both basal and internodal. To get an accounting of variability, 100 softwood cuttings were tested. They were treated with a root-inducing formulation consisting of 0.8% indolebutyric acid in talc with the fungicide Thiram added at the rate of 15%. Mid-June was considered to be an optimum time for the collection of softwood cuttings. On June 16, the cuttings were collected and inserted under mist in a greenhouse bench with bottom heat maintained at 75°F. The medium consisted of peat moss and perlite in equal parts. Thirty-nine days later they were lifted and evaluated. The results are summarized in Table 1.

Table 1. Root distribution on *H anomala* subsp *petiolaris* cuttings.

Location of Roots	Percentage
Basal roots only	32
Internodal roots only	34
Both basal and internodal	14
Failed to root	 20
TOTAL	100

Cuttings of 2 and 3 year old wood, bearing holdfasts were pulled from a stone wall and tried. They were tested to find

Figure 3. Functioning roots developed between nodes in positions normally occupied by holdfasts.

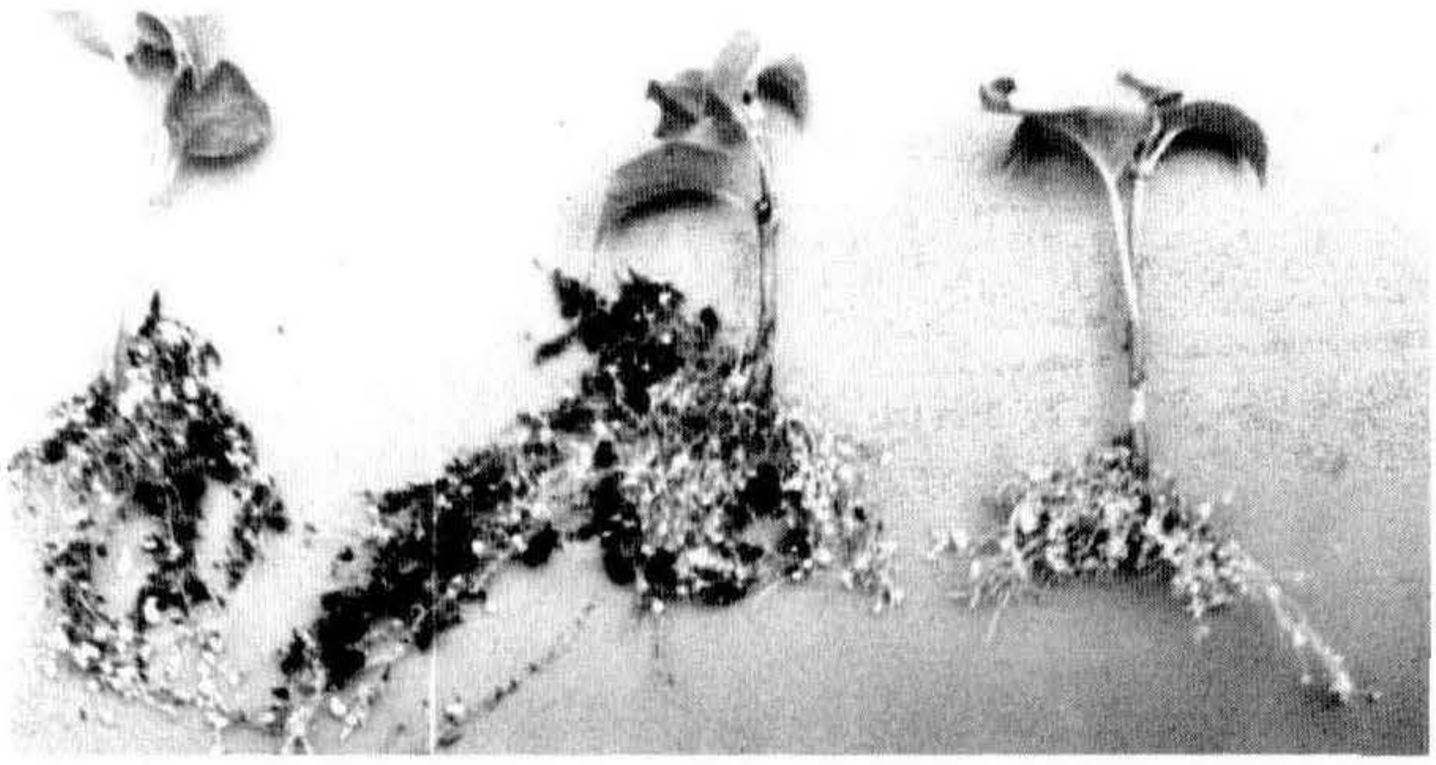

Figure 4. Roots on 32% of the *Hydrangea anomala* subsp. *petiolaris* cuttings rooted at their bases.

whether or not functioning roots would develop when holdfast roots were already present. Preparation and treatment was similar to that described above. An abundance of functioning roots appeared on this material and all were internodal. The roots on each cutting arose in a vertical line parallel to the row of holdfasts.

PROPAGATION OUT-OF-DOORS UNDER MIST

At the Hoogendoorn Nurseries, Newport, Rhode Island, *H. anomala* subsp. *petiolaris* cuttings have been rooted out-of-doors under mist for many years. They are taken about the third week in June and only sand is used as a medium. In the absence of bottom heat, the cuttings root much slower than those described above and roots do not appear until September. Mr. Case Hoogendoorn cautions that the rooted cuttings must be protected against even a few degrees of frost as they are highly vulnerable to splitting. Therefore, in autumn they are lifted, flatted in a medium of damp peat moss and perlite, and placed in a 40°F

cold storage unit. In March they are potted and transferred to a frost-free frame where they remain until the following spring. At this time they are ready to be sold

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PLANT PATENTS AND LEGALITIES

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Article I of the Constitution of the United States grants Congress broad powers to enact legislation to "promote the progress of science and the useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

In 1793, the Congress enacted the Patent Act, which was authored by Thomas Jefferson. The Act, which was subsequently modified in 1836, 1870, 1874, and 1952, is essentially the same today as it was written by Jefferson.

In 1930, the Plant Patent Act was enacted to afford patent protection to certain asexually reproduced plants Before this time there were two factors which were thought to exclude plants from patent protection. First was the general belief that plants were products of nature, even though artificially bred. The second factor was that it was not thought that new varieties of plants could be adequately described by the written word. In passing the Plant Patent Act, the Senate, in its report on the Act, explained that the work of the plant breeder "in aid of nature" was a patentable invention. The Congress relaxed the written description requirement by providing for a "description as complete as reasonably possible."

Questions most frequently asked about the Plant Patent Law are:

1. What is a plant patent?

   A plant patent is a grant by the Government to an inventor (or his heirs or assigns) who has invented or discov-

cold storage unit. In March they are potted and transferred to a frost-free frame where they remain until the following spring. At this time they are ready to be sold

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Questions most frequently asked about the Plant Patent Law are:

1. What is a plant patent?

   A plant patent is a grant by the Government to an inventor (or his heirs or assigns) who has invented or discov-

ered and asexually reproduced a distinct and new variety of plant, other than a tuber propagated plant or a plant found in an uncultivated state, the grant being the right to exclude others from asexually reproducing the plant or selling or using the plant so reproduced.

2. For how long a term of years is the patent granted?

   Seventeen years from the date which it is issued.

3. How does a plant patent differ from other kinds of patents?

   A plant patent relates to a living plant which as a product of nature obviously cannot be "made" or "manufactured " In a utility patent (regular patent) the grant confers "the right to exclude others from making, using or selling" the invention; in a plant patent the grant confers "the right to exclude others from asexually reproducing the plant or selling or using the plant so reproduced."

4. Does a plant patent carry with it a guarantee of quality or merit.?

   No. The issuance of a plant patent is not the equivalent of an endorsement by the Government of quality and merit The only implication which can be drawn from the grant of the patent is that the plant is "distinct and new "

5. Is there any restriction as to persons who may obtain a United States plant patent?

   No. Any person may obtain a plant patent by complying with the provisions of the law. A foreign citizen may obtain a U S. plant patent under exactly the same conditions as a U.S. citizen.

6. Can there be joint inventors in an application for a plant patent?

   Yes. If each person had a share in the ideas resulting in the breeding of a new variety of plant, or if, in the case of found plant, more than one made the discovery, they may be joint applicants for a plant patent.

7. What new types of plants are patentable?

   New and distinct varieties of plants fall roughly into three classes· (1) sports, (2) mutants, and (3) hybrids. In the case of sports, the new and distinct variety results from bud variation and not seed variation. A plant or portion of a plant may suddenly assume an appearance or character distinct from that which normally characterizes the variety or species. In the case of mutants, the new and distinct variety results from seedling variation by self-pollination of species. In the case of hybrids, the

new and distinct variety results from seedlings of crosspollination of two species, of two varieties, or a species and a variety. In this case, the word "hybrid" is used in its broadest sense.

8. May new and distinct plants found growing in nature be patented?

   Yes. The present law indicates clearly that plant seedlings discovered, propagated asexually, and proved to have new characteristics distinct from other known plants, are patentable. The law, howver, specifically excludes plants found in an uncultivated state.

9. What are some of the characteristics that may distinguish a new variety of plant?

   The characteristics that may distinguish a new variety of plant would include, among others, those of habits; immunity from disease; resistance to cold, drought, heat, wind, or soil conditions; color of flower, leaf, fruit or stems; flavor; productivity, including everbearing qualities in fruits; storage qualities; fragrance; form; and ease of asexual reproduction.

10. How are plant varieties classified in the Patent Office?

    There are 89 subclasses in the class of plants. The major subdivisions are: roses; nuts; fruits; conifers; broadleaf; trees; shrubs or vines; herbaceous flowering plants; herbaceous ornamental foliage plants; and miscellaneous plants such as mushrooms and sugarcane.

11. What are some of the prerequisites for filing an application for a plant patent?

    The new plant variety: must have been asexually reproduced by the applicant; must not have been described in a printed publication nor introduced to the public nor placed on sale more than one year before filing of the application; must have originated either (a) as the result of some act of cultivation by the applicant, e.g. cross pollination, treatment, selection and/or breeding efforts, (b) as a seedling found by the applicant in a cultivated area, or (c) as a sport found by the applicant.

12. Of what does a patent application consist?

    A written document comprising a petition, specification and claims describing and defining the new plant, an oath or declaration, a drawing in those cases in which a drawing is possible, or a photograph, and payment of the filing fee.

    The application papers must be filed in duplicate. When color is a distinguishing characteristic of the new variety,

the drawing or photograph must be in color and two copies must be submitted.

The oath or declaration required of the applicant, in addition to the averments required in the conventional oath or declaration for other patents, must state that he has asexually reproduced the plant. Where the plant is a newly found plant, the oath must also state that it was found in a cultivated area

The description of the plant variety as given in the specification should be complete and detailed and expressed in botanical terms in the general form followed in standard botanical textbooks It is mandatory that the specification include the origin or parentage of the plant sought to be patented and where (geographic) and in what manner (cuttings, grafting, etc) the plant has been asexually reproduced When the color is a distinctive feature of the plant, the color should be positively identified in the specification by reference to a designated color atlas or dictionary. When the plant originated as a newly found seedling, the specification must particularly point out the location and character of the area where the seedling was discovered to establish that it was not found in an uncultivated state

13 Is it necessary to submit specimens of the plant variety, its flower or fruit when filing the application?

No Specimens of the plant variety, its flower or fruit should not be submitted unless specifically called for by the examiner.

In addition to the Plant Patent Act, which covers asexually reproduced plants, we have the Plant Variety Protection Act, which covers sexually reproduced plants. This Act was passed in 1970 to provide certificates of Plant Variety Protection to breeders of any novel variety of sexually reproduced plants.

The Plant Patent Act specifically excludes tuber propagated plants from protection The Plant Variety Protection Act when passed excluded six vegetables from protection. These were okra, celery, peppers, tomatoes, carrots and cucumbers. This exclusion was removed by a bill passed by Congress this week (December 8-12, 1980) which now awaits the President's signature.

The protection offered by the Plant Patent Law and Plant Variety Protection Acts differs slightly. The Plant Patent Law protects the patent holder against asexual reproduction of his patented plant, whereas the holder of a Plant Variety Protection Certificate is protected against either sexual or asexual reproduction of the protected plant The term of the grant in both instances has been 17 years. The changes to the Plant Variety

Protection Act passed this week change the term of the grant on sexually reproduced plants to 18 years to bring the Act into conformity with the International Convention For The Protection Of New Varieties Of Plants.

One might ask what benefits accrue to the public from the Plant Patent Law.

Since the enactment of the Plant Patent Law in 1930, research and development in many areas of plant breeding have significantly increased. As a natural outgrowth of increased research, many improvements have been forthcoming. In varieties of fruits and nuts we have seen improved flavor; better form, increased size; increased yields; harvest spread over longer seasons; fruits which are adapted to mechanical planting, growing, harvesting and grading, with improved "keeping" qualities that permit them to be shipped over a much wider area.

In environmental plans, the public has seen improvements in the form of the plant, in vigor of plant growth, hardiness and disease resistance; and in the flowers, improved form, color, fragrance and lasting quality.

Improvements as a direct result of the Plant Patent Law are so great that many fruits which were popular 50 years ago have been entirely supplanted by newly developed cultivars brought about by the favorable climate for plant development. Only a few of the cultivars of rose and chrysanthemums which were grown in our gardens in 1930 are still commercially available because they too have been supplanted by new and improved cultivars. We have many more hardy plants now — azaleas are a good example of what intensive breeding programs can do.

The Plant Patent Act has given the consumer-public protection from unscrupulous promoters in two ways: The Patent owner within certain limits, can keep a patented plant from being produced and sold by growers not qualified to produce the quality to which the public is entitled; and through the use of the cultivar name associated with the patented plant, to assure the consumer of getting the true cultivar. Before the days of the Plant Patent Law an unscrupulous grower could easily take a superior new cultivar, rename it as his own, and freely enjoy the benefits of another's work.

By the same token, you might ask what are the benefits of the Act to the hybridizer or plant breeder.

The Plant Patent Act made it possible for a hybridizer to specialize and concentrate his attention on developing new plants. He is no longer forced to divide his time and efforts by being concerned with production to support his hybridizing program. If he is skilled in the art, he can become a specialist in the field of hybridizing and support himself and even profit from his

time and investment.

A nurseryman who owns a patented plant can afford to educate the public and other nurseries on the benefits of the invention. The patented plant, therefore, comes into wider use more quickly than would be possible without such education. If he did not have patent protection, education would be impractical and the public might be denied the benefits until it became known; usually a slow process.

Plant Patents have upgraded the nursery industry. This has occurred through the development of superior new products brought about by the increased research made possible by the Plant Patent Law.

It is interesting to point out that due to the encouragement of the U.S. Plant Patent Law, a number of foreign hybridizers have been able to expand their research and breeding. This is also of direct benefit to the nursery industry in the United States and the ultimate benefit of the American public. The more important aspect of this, however, is that, following the lead of the United States, many countries have granted patents on new plants. This has stimulated the interest of American breeders in promoting their new plant cultivars in these countries, which in its small way contributes to international good will and may contribute to a favorable balance of trade for the United States.

The nursery industry exists only because there is a public demand for plant material. The Plant Patent System enables the industry to allocate money for research and development of new and better cultivars to satisfy that demand. The American landscape would be less colorful and interesting for all if it were not for patented plants.

As mentioned earlier, the only amendment to the Plant Patent Act became law on September 3, 1954, to permit the patenting of "newly found seedlings." This amendment in itself seems to recognize and establish that the significant part of the inventive act is the discovery and preservation of a new and distinct plant rather than the particular cross that may have brought it about. A careful examination of the historical background of Plant Patents demands recognition of the fact that unusual skill is required in the discovery or selection process.

The Plant Patent Law is a workable and proven law. It has withstood the test of time and the courts. We often find breeders making the same crosses, but we have yet to see a case of interference as a result of the duplication of such crosses. More than 4600 Plant Patents have been granted. The number contested as to validity in the Federal Courts number less than 3 dozen. No Plant Patent has been declared invalid for failing to meet the standard of unobviousness.

Since the Plant Patent Act came into force, the Patent Office has held consistently that the term "plant" as used in the Act, meant "plant" in the ordinary and accepted sense "in the common language of the people," but not in the strict scientific sense. This definition excluded bacteria, but included fungi.

A recent landmark decision of the Supreme Court involved the patenting of a bacteria. The case at issue was Sidney A. Diamond, Commissioner of Patents and Trademarks, versus Ananda, Chakrabarty *et al.* Chakrabarty, a microbiologist, filed a patent application for a bacteria which is capable of breaking down multiple components of crude oil. This bacterium would be able to "eat" oil spills, thus eliminating environmental contamination. His application was denied by the patent examiner on the basis that, first, micro-organisms are "products of nature" and, second, that as living things they are not patentable.

Chakrabarty appealed to the Patent Office Board of Appeals, and the Board upheld the examiner on the second grounds. This decision was reversed by the Courts of Customs and Patent Appeals.

The Commissioner of Patents, obviously wanting a definitive decision on the law, filed writ of certiorari to the Supreme Court. Very briefly, the Supreme Court held that the patent should be granted. Some of the comments of the Court in this case are of extreme importance in respect to the Plant Patent Act and Plant Variety Protection Act.

The government leaned heavily on the theory that enactment of the Plant Patent Act in 1930, and the Plant Variety Protection Act in 1970, evidenced Congressional understanding that the terms "manufacture" or "composition of matter" did not include living things. If they did, the government argued the Acts would not have been necessary.

The Court rejected this argument

Next the government argued that micro-organisms cannot qualify a patentable matter until Congress expressly authorizes such protection. This argument was predicated on the fact that genetic technology was unforeseen when Congress enacted the Patent Law. This argument was also rejected.

In rejecting these arguments, the Court held strongly to the Jeffersonian philosophy that "ingenuity should receive liberal encouragement." Also, the Court noted that Congress, in 1952, expressed the intent that the law "include anything under the sun that is made by man." Under these conditions, neither the Plant Patent Law nor the Plant Variety Protection Act were necessary since the general Patent Laws are broad enough to provide protection to plants reproduced either sexually or asexually.

In closing, the Plant Patent Act has well attained its purpose

of affording a sound basis for investing capital in plant breeding and, consequently, stimulating plant development through private enterprise. The more than 4600 Plant Patents issued have been developed by private industry without the help of Government funds. Many of these patents cover food bearing plants, plants that are of better quality, offer higher yields, require less care because of their resistance to insects and disease, and, as a result, make available to the consumer a cheaper, better product. The Plant Patent Act has also led to the development of ornamental plant material which is resistant to disease, drought and cold, all without the aid of Federal funds.

COMMERCIALLY-FEASIBLE MICROPROPAGATION OF MOUNTAIN LAUREL, *KALMIA LATIFOLIA*, BY USE OF SHOOT-TIP CULTURE

GREGORY LLOYD AND BRENT McCOWN

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Abstract. The multiplication at rates feasible for commercial production of mountain laurel, *Kalmia latifolia*, by micropropagation using shoot-tip cultures has been demonstrated Shoot-tip explants placed initially in liquid woody plant medium (WPM) supplemented with 4-16 μM N^6-(Δ^2-isopentenyl)-adenine (2iP) produced axillary shoots by 1 to 2 months. These new shoots were excised from the original explant and placed on the same WPM solidified with agar The resultant shoot mass was subcultured monthly Actively multiplying shoot-tip cultures were produced within 6 months A comparison of 7 concentrations of 2iP, varying from 0 to 64 μM, showed that a concentration of 8 μM 2iP produced the greatest number of utilizatble shoots after 8 weeks in culture Stock cultures were maintained or increased monthly by removing and subculturing shoots elongating from the basal mass. Thirty to forty utilizable shoots were harvested from each culture 6 to 8 weeks after the initial subculture Multiplication rates of 8 to 10 times were readily achieved Harvested shoots rooted with 73% success in 4 to 6 weeks when placed in a 100% peat medium in a high humidity chamber. After a period of acclimation, these plants can be treated like young seedlings in commercial production

"We invite you to rediscover the long-neglected laurels, a favorite and familiar American plant. But we warn you that you may experience some frustration, for mountain laurel selections are at present difficult to root and slow growing" (2). However, the situation is improving. A number of programs continue to

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find mountain laurel genotypes with superior ornamental value. If named selections are to receive wide distribution, rapid and dependable asexual propagation techniques will be essential. Grafting is feasible but adds considerable expense in production. Success with cuttings varies markedly with the individual genotype and age of the stock plant (2,3). Micropropagation may be a practical solution for the multiplication of unique and desirable mountain laurel selections.

Micropropagation on a potentially commercial scale has been demonstrated for a number of woody species (1,3,5). McCown and Amos (4), working with a number of birch species, have achieved propagation rates that yield 500,000 plantlets per year using only 125 sq. ft. of culture shelf space. Although field growth rates of the micropropagated plants were different than the average seedling, the micropropagated plants did acclimate readily to greenhouse conditions.

Stem-tips were removed from actively growing, 3 year old *Kalmia latifolia* seedlings. After removal of most of the leaves, the explants were dipped in 70% ethanol and then treated for 10 to 15 minutes with 10% household bleach (sodium hypochlorite) with a wetting agent added (0 05% Tween-20). After rinsing 3 times in sterile distilled water and removing any injured tissue, the explants were placed individually in 50 ml Erlenmeyer flasks containing 15 to 20 ml liquid woody plant medium (Table 1) supplemented with 4 to 16 μM 2iP. The liquid medium was changed after 12 and 24 hours and on a daily basis for one week thereafter. After one week the explants were transferred to stationary test tubes and liquid medium was added to a depth of ½ the height of the explant. The medium was changed every 3 weeks. After 1 to 2 months the explants produced axillary shoots (Fig. 1) These shoots were removed when approximately 2 cm long and placed on the same WPM solidified with 0.6% agar. If any exudation from the explants occurred, they were moved to fresh medium. Cultures were transferred to fresh medium once a month and at this time any malformed tissues were discarded. After 6 months in culture, all surviving explants showed active and uniform shoot growth and multiplication (Fig 2).

Cultures were grown in rooms with 24 hour cool white fluorescent lighting (20 $\mu Em^{-2}sec^{-1}$) and temperatures that averaged 28° to 30°C. Culture vessels were either 1 oz or 4 oz glass bottles containing 10 ml and 30 ml of medium respectively, and were capped with Parafilm-M.

The shoot-tip cultures were multiplied by removing several elongating shoots from the basal mass and subculturing the shoots on fresh medium. Dividing and subculturing the basal shoot mass as has been successful with birch stock cultures (4) caused exces-

Table 1. Composition of Woody Plant Medium[1]

Stock		g/l	ml/l	final conc (mg/l)
A	NH_4NO_3	20 0	20	400
	$Ca(NO_3)_2$ 4HOH	27 8		556
B	K_2SO_4	49 5	20	990
C	$CaCl_2$ 2HOH	19 2	5	96
D	KH_2PO_4	34 0	5	170
	H_3BO_3	1 24		6.2
	Na_2MoO_4 2HOH	0 05		0 25
E	$MgSO_4$ 7HOH	74 0	5	370
	$MnSO_4$ HOH	4 46		22 3
	$ZnSO_4$ 7HOH	1 72		8 6
	$CuSO_4$ 5HOH	0 05		0 25
F	$FeSO_4$ 7HOH	5 57	5	27 8
	Na_2 EDTA	7 45		37 3
G	Thiamine HCl	0 2	5	1 0
	Nicotinic acid	0 1		0.5
	Pyridoxine HCl	0 1		0 5
	Glycine	0 4		2 0
H	Myo-inositol	20 0	5	100
I	Sucrose			20 g/l
J	Agar			6 g/l

Stock F Dissolve each component in 200 ml water, heat each, mix while hot, stir as cools to room temp (4-6 hrs) Final vol of 1 liter

[1] Woody Plant Medium (WPM) developed by McCown and Lloyd (University of Wisconsin) for shoot-tip and callus cultures of birch, rose, rhododendron, oak and other dicot ornamental species Hormone supplements usually include benzyladenine (2 to 16 μM) or 2iP (4 to 32 μM) for shoot-tip cultures, and a cytokinin and an auxin (0 4 to 4 μM) for callus stock and callus differentiation Final pH without agar is adjusted to 5 2 using KOH

sive tissue breakdown and exudation which resulted in poor shoot growth.

A comparison of shoot production rates on 0, 2, 4, 8, 16, 32 and 64 μM 2iP was performed to determine the optimum 2iP concentration for shoot multiplication. A 2 cm long shoot from an actively growing shoot-tip culture was subcultured onto 10 ml of medium in a 1 oz bottle supplemented with one of the 7 2iP concentrations. Each concentration was replicated 20 times. After 4 weeks, the 10 best cultures were transferred to fresh medium and then harvested after an additional 4 weeks of growth. Results (Fig. 3) showed an optimal shoot production rate at 8 μM 2iP. Lower levels of 2iP gave fewer but larger shoots and higher 2iP levels caused stunting of shoot growth.

Shoots can be harvested from actively growing cultures 8 weeks after the initial subculture. A 4 oz bottle containing 30 ml of medium supplemeted with 8μM 2iP will produce 30 to 40 utilizable shoots, 1 to 2 cm in length, if the initial subculture contained four 2 cm explants and the tissue was transferred to fresh medium after 4 weeks of growth (Fig. 4). This represents an 8 to 10 time multiplication rate. Harvested shoots were very

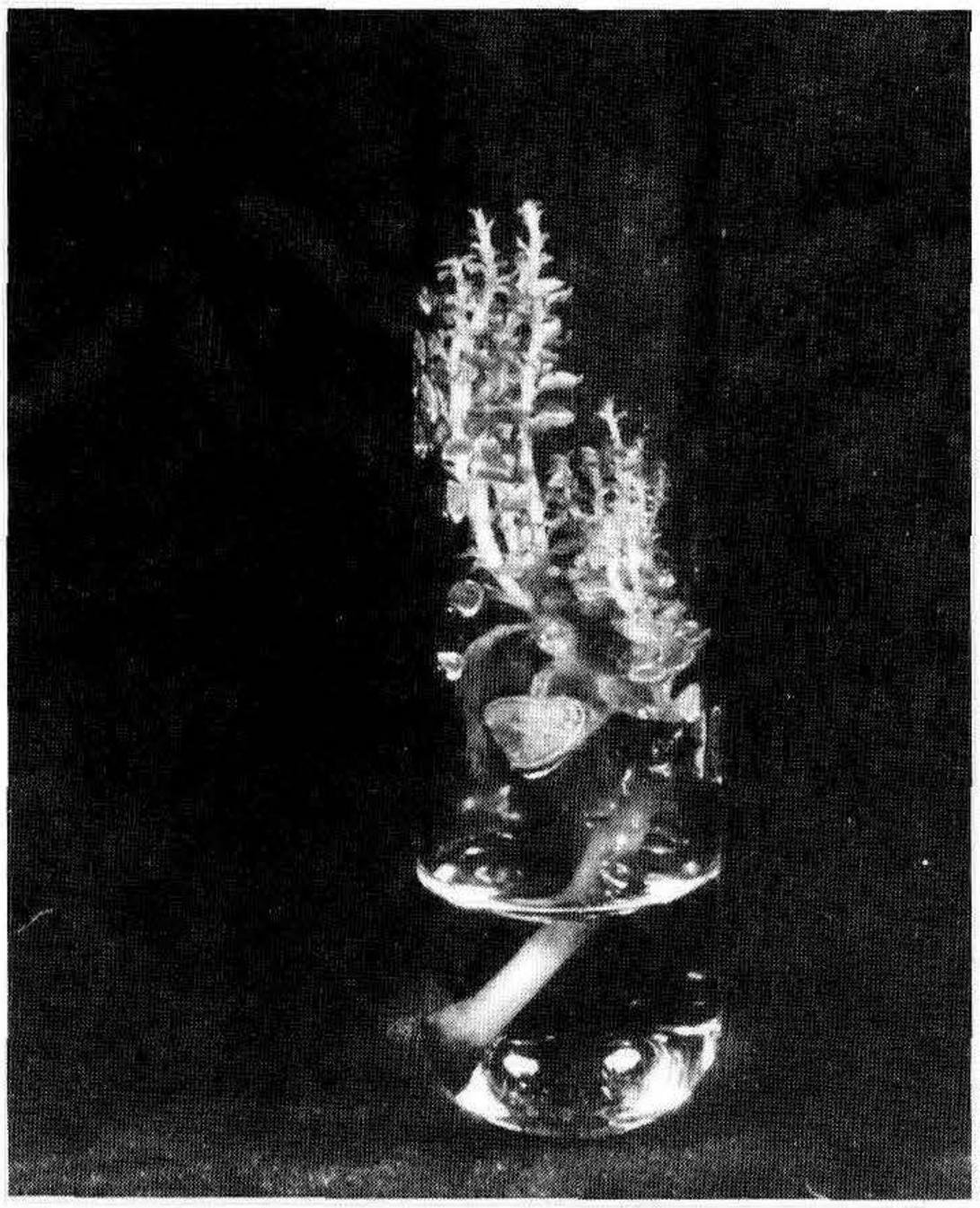

Figure 1. Axillary shoots that have developed from the original explant of mountain laurel, *Kalmia latifolia,* after 1 to 2 months in culture. The medium is woody plant medium (WPM) supplemented with 2iP. The axillary shoots are excised and placed on the same woody plant medium solidified with 0.6% agar for shoot multiplication.

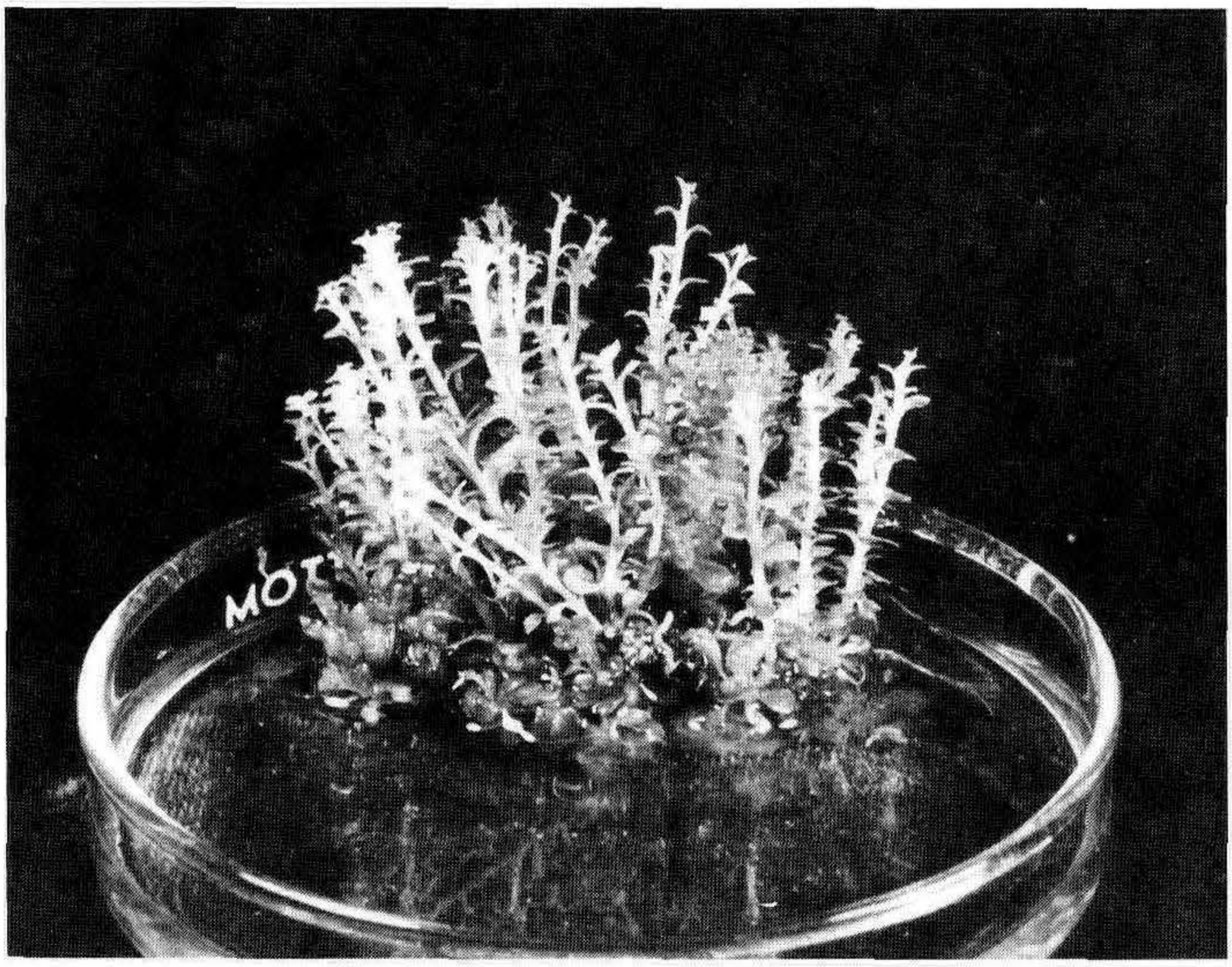

Figure 2. An actively growing shoot-tip culture of mountain laurel, *Kalmia latifolia, 6 months after isolation of the original explant. Cultures were* subcultured at least monthly on woody plant medium (WPM) supplemented with 2iP and solidified with 0.6% agar.

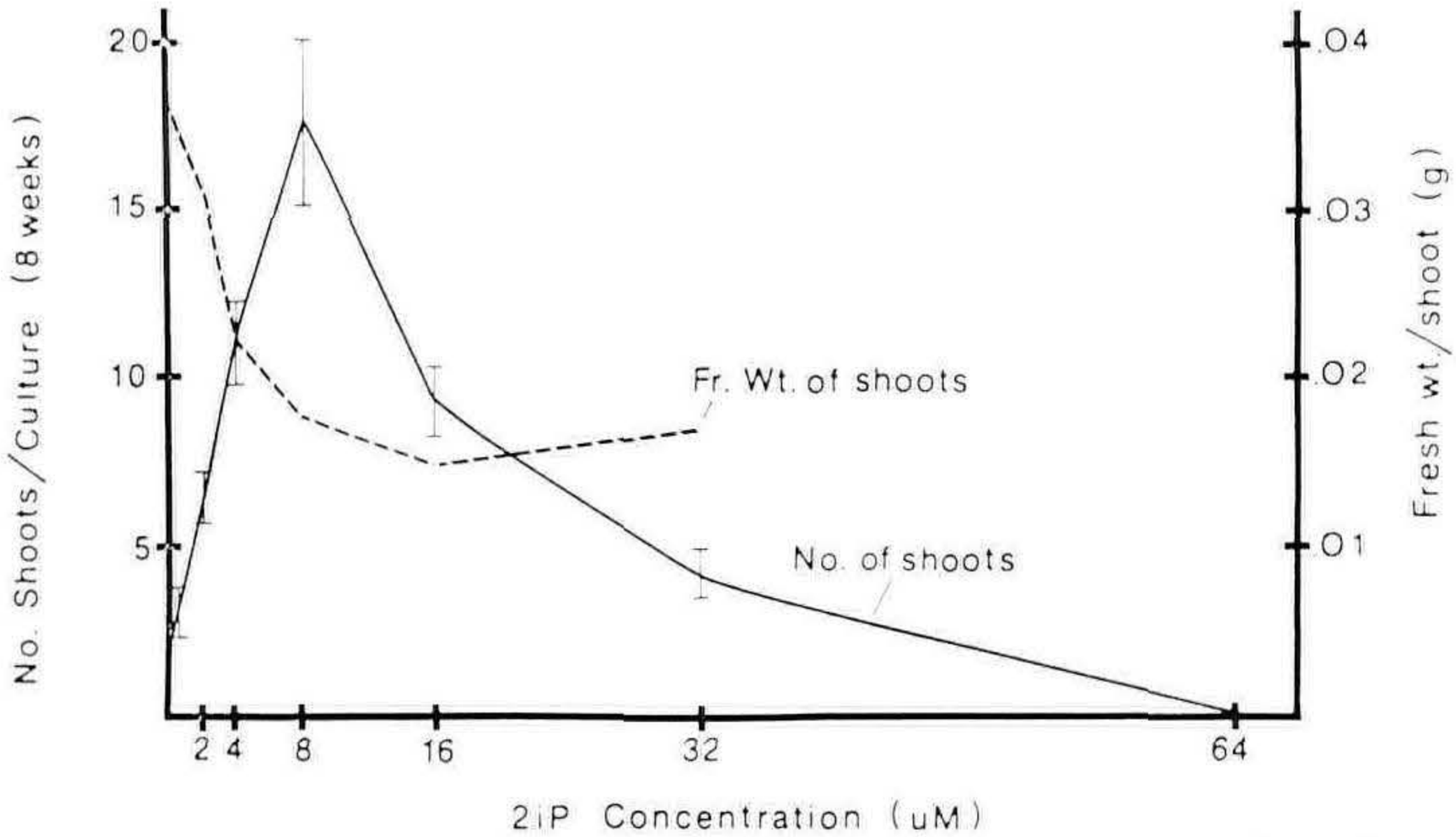

Figure 3. The response of shoot-tip cultures (±SE) of mountain laurel, *Kalmia latifolia*, to the concentration of the cytokinin 2iP (N_6-)Δ_2-isopentenyl)-adenine) in the medium. The medium was woody plant medium (WPM) solidified with 0.6% agar. Cultures were derived from a 2 cm shoot originating from a shoot-tip culture. Cultures were subcultured at 4 weeks onto fresh test medium and shoots harvested after a total of 8 weeks of growth.

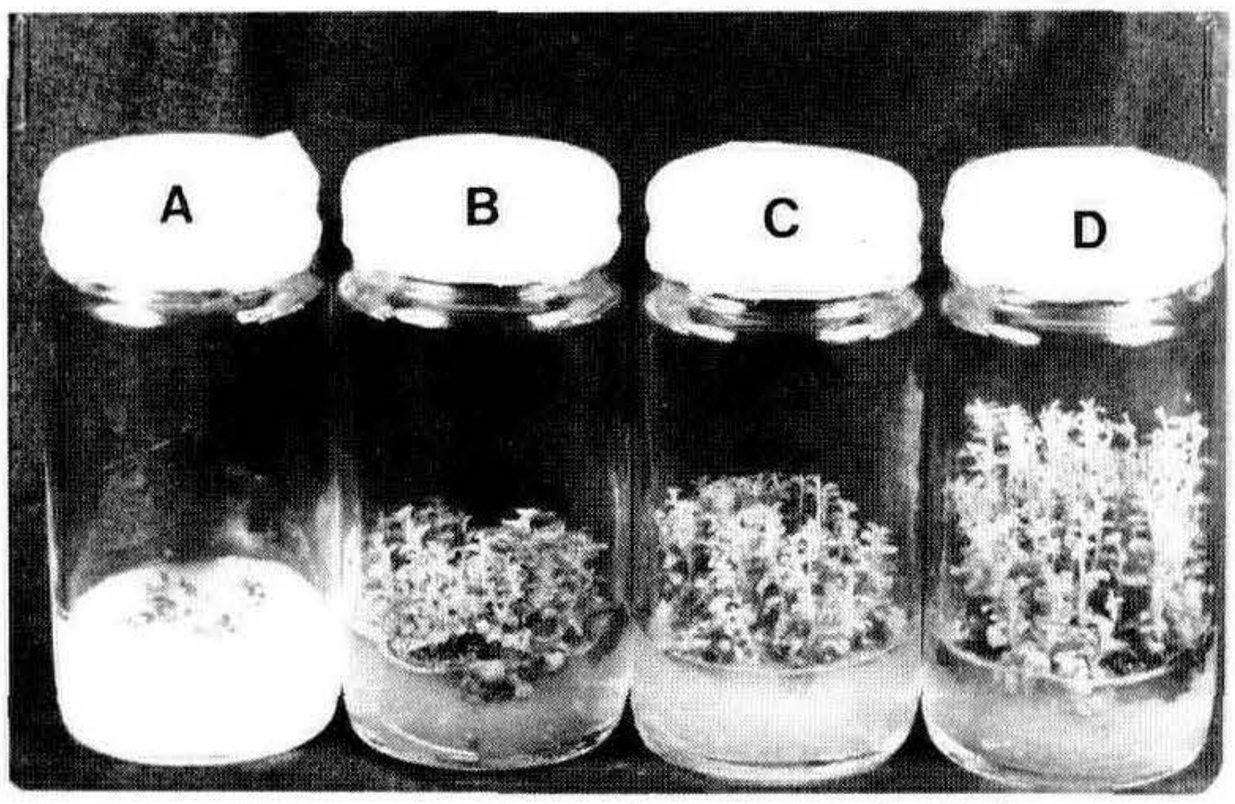

Figure 4. Four cultures of mountain laurel, *Kalmia latifolia*, showing the progressive development of shoot-tip cultures. A, the initial culture consisting of four 2 cm long microshoots; B, the culture after 4 weeks of growth; at this stage the shoot mass will be subcultured to new medium; C, the culture after a total of 6 weeks of growth; D, the final shoot-tip culture ready for shoot harvest and/or further shoot multiplication of the culture.

subject to desiccation and thus were cut into water and remained wet until placed in the rooting environment.

Shoots were rooted in 100% peat medium in a warm (30° to 35°C), high humidity chamber under 24 hour cool white fluorescent light (30 $uEm^{-2}sec^{-1}$). Rooting occurred within 4 to 6 weeks with a 73% success rate. The microcutting showed good root distribution and development (Fig. 5). Hormone treatments did not appear to be necessary. Once rooting occurred, the plants were shifted to a greenhouse and gradually given full sunlight and lower humidity over a 2 week period. At this stage, the plants can be treated as seedlings in normal nursery production programs.

Figure 5. Typical rooted microcuttings of mountain laurel, *Kalmia latifolia*, derived from shoot-tip culture and rooted in a high humidity chamber. A, initial microcutting taken from a shoot-tip culture; B, microcutting after 2 weeks in the rooting chamber; C, microcutting after 6 weeks in the rooting chamber; plant is ready for acclimation to greenhouse environment; D, plant after 2 weeks acclimation in greenhouse; E, plant after 2 weeks further growth in the greenhouse.

The rate of multiplication appears adequate for commercial purposes. Producing an average of 30 shoots per culture in 8 weeks yields at least 7000 shoots per 1 sq ft of culture shelf space per year. With a 73% rooting success, this represents approximately 5000 useable propagules. Although 3-year-old seedlings were used in this study, success has also been achieved with rooted cuttings taken from mature, flowering plants.

Besides rapid multiplication and a minimal space requirement for stock plant maintenance, additional benefits of the use of micropropagation are potentially disease-free propagules, and dependable, easily controlled uniformity of propagules. These factors would be particularly advantageous in accelerated growth programs where a predictable response to cuture conditions is extremely important. Accelerated growth conditions may then be used to overcome the second major problem in commercial production of mountain laurel, the normally slow growth exhibited by most *K. latifolia* plants.

The micropropagation techniques used here employed shoot-tip cultures where shoots evolved from preformed meristems on the original explants and not adventitious shoot regeneration from callus. Thus, given a relatively stable genotype initially, the genetic stability of the culture should remain high. The only abnormality observed is an occasional fastigiation of a shoot in culture. Such abnormalities can easily be selected against in normal stock culture maintenance.

Further research on treatments to increase rooting success and on field growth characteristics of micropropagated plants would be useful.

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4 McCown, Brent H and R Amos 1979 Initial trials of commercial micropropagation with birch *Proc Inter Plant Prop Soc* 29 387-393

5 Cheng, Tsai-Ying and Thanh H Voqui-Dinh 1979 Clonal propagation of selected deciduous trees through tissue culture *HortScience* 14 457 (Abstr)

Friday Morning, December 12, 1980
NEW PLANT FORUM

Jack Alexander and Gary Koller, Moderators

MODERATOR ALEXANDER: Our first speaker today is Dr. Richard Jaynes.

DICK JAYNES: *Kalmia latifolia* 'Pink Charm' was selected from the progeny of a controlled cross (x1078) made in 1970 between two unnamed pink-flowered selections obtained from Weston Nurseries, Hopkinton, Massachusetts. The plant first flowered in the fourth growing season, 1974, and has flowered every year, except one, since then. The flower buds are red in color (RHS Colour Chart 53C), but less brilliant than the red-buds: 'Nipmuck', 'Ostbo Red', and 'Quinnipiac'. The open flowers are a rich pink being more deeply pigmented than the earlier named 'Pink Surprise'. The inside of the corolla is a relatively uniform pink (RHS 54B but a bit lighter and towards 55B, or 67D). A narrow and deeply red pigmented ring occurs on the inside and near the base of the corolla.

In additlion to floral traits, 'Pink Charm' was selected for the relative ease by which the cuttings root. Small numbers of cuttings have been stuck for each of the past five years in a humidity case, peat:perlite mix (5:2 v/v), bottom heat 70 to 75°F, and no auxin. Cuttings were taken mostly in October, but also December 30 and January 21 (Table 1). Overall success of rooting averaged 76%, or 82% if only the fall stuck cuttings are considered.

Plant habit and foliage of 'Pink Chrm' are characteristic for the species. Limited quantities of cuttings are available from R.A. Jaynes, Connecticut Agricultural Experiment Station, P.O. Box 1106, New Haven, CT 06504. Also, Briggs Nursery, Olympia, Washington 98501 is propagating this selection by tissue culture, along with three other *Kalmia latifolia* cultivars and is taking orders for small plants.

Kalmia latifolia 'Shooting Star' is a selection from the wild in North Carolina. This cultivar has 5 deeply cut lobes that reflex.

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Table 1. Rooting of *Kalmia latifolia* 'Pink Charm' cuttings over a period of five years

Date struck	No cuttings	No rooted	Percent rooting
10/4/74	15	15	100
10/21/75	12	10	83
10/8/76	35	22	63
12/30/77	24	20	83
10/5/77	30	25	83
1/21/79	20	6	30
10/4/79	20	20	100
Total	156	118	ave 76

The cut corolla is a single recessive gene. This cultivar is under tissue culture propagation

Kalmia latifolia 'Goodrich' is a continuous banded type that virtually fills the inside of the corolla. It is difficult to root. This trait is a single dominant gene type.

MODERATOR ALEXANDER. Paul Meyer has 3 plants to show us

PAUL MEYER· *Ulmus parvifolia,* the Chinese elm, has great potential as a medium sized urban street tree. This species ranked highest of the 15 reviewed in a recent Morris Arboretum study of street trees planted in Philadelphia 15 years ago. It is resistant to the Dutch elm disease and most leaf eating insects which frequently plague elms Also, it is tolerant of the variable soil conditions found in urban environments.

Chinese elms grow quickly when young and mature at about 50 feet. It has a fine texture with small dark green leaves. The bark of young branches exfoliates revealing a mosaic of tan and orange inner bark. The Chinese elm should not be confused with the wéedy Siberian elm *(U. pumila)* which is a very weak wooded species. Chinese elm, unlike the Siberian elm, flowers in September and its seed ripens by late October.

At the Morris Arboretum Chinese elm seeds have been easily germinated after 3 months moist stratification.

Evodia daniellii Few trees can match the late summer splendor of Korean evodia. In late July large clusters of creamy white flowers appear These provide a good source of nectar for honey bees at a time when other flowers are scarce. They are followed in mid-August by bright red fruit clusters which persist into early October.

The Korean evodia grows quickly to a mature height of 50 feet. Like most members of the rue family it has few insect or disease problems. Its smooth gray beech-like bark is an asset all seasons of the year It is reputed to be somewhat weak wooded though I have not noticed this to be a problem.

The Korean evodia is propagated easily from seed and re-

quires no stratification.

Acer buergeranum, the trident maple, is an excellent medium sized (45') shade tree with interesting year round character. It has glossy light green leaves which are highly resistant to most disease and insect problems. In the autumn the tree turns to a rainbow of reds, oranges, and yellows. Its tan, shreddy bark slowly peels away as it matures revealing the orange inner bark.

In its native Japan, trident maple is widely planted as a street tree and a few reports indicate that it is similarly adaptable here. It is also well suited as a shade tree in small urban and suburban gardens. Its relatively small size and fine texture make it more useful than the eastern north American maples in confined spaces.

Trident maple seeds germinate quickly after three months moist stratification. It is fast growing as a young tree. It often has a tendency to branch close to the ground but with early pruning it can be trained to develop a high crown.

Seeds of *Acer buergeranum, Evodia daniellii* and *Ulmus parvifolia* are available from Paul W. Meyer, Curator, 9414 Meadowbrook Avenue, Philadelphia, PA. 19118. Telephone 315-247, 5777

MODERATOR ALEXANDER: Jeanne Smith, University of Georgia, has a plant to show us.

JEANNE SMITH: I have been observing the native plants in Georgia and surrounding states. One of the plants that I think deserves wider planting for its ornamental bark characteristics is *Clethra acuminata*, the sweet mountain pepper bush. This plant is a large multistemmed plant that will reach 15 to 20 ft. Its most attractive feature is the cinnamon-purple exfoliating bark. The plant blooms in July with white terminal racemes. The fall color is yellow to yellowish-brown. Seeds germinate readily in 10 to 14 days without stratification. The plant appears to grow best in partial shade with moist soil conditions.

MODERATOR ALEXANDER: Ed Losely has some plants to show us.

ED LOSELY: *Fothergilla gardenii* is grown in our nursery and we find that it can be rooted from softwood cuttings in May-June. To successfully overwinter it you must not disturb the plants. We put them in a minimum heat house over the winter.

Lindera angustifolia (Ed. note: see New Plant Forum, Proc. Inter Plant Prop. Soc., 27:494).

Cyrilla racemiflora, southern leather wood, is hardy to perhaps −20°F. I believe that there are different strains varying in hardiness. The plant blooms in the June-July period with white flowers that are very attractive to bees. We propagate it from

softwood cuttings in the summer

Ilex verticillata 'Aurantiaca' is different from the species by having orange fruit

Hamamelis vernalis 'Carne' is a red flowering form.

Exochorda giraldii var. *wilsonii* is a plant that we have observed but have not propagated. It is a very intense spring flowering plant with flowers about 2 inches across. It is hardy at Holden Arboretum.

MODERATOR ALEXANDER: The next speaker is Ray Maleike.

RAY MALEIKE: The southern blackhaw — *Viburnum rufidulum*, is a native American viburunum distributed over the lower half of the United States from Virginia through Southern Illinois and into Texas. It is a large shrub to a small tree and may be trained accordingly Height may attain 30 ft. (10m)

It is easily distinguished from a close relative V. *prunifolium*, blackhaw, by, first of all, being taller at maturity. The southern blackhaw's leaves are more coriaceous, elliptical to obovate rather than ovate to elliptical and very lustrous. Buds are an intense bright brown and tomentulose.

Flowers are white, flat-topped and cymose, and up to 4″ in diameter. They appear with or shortly after the leaves and at the same time as V *lentago* and V. *plicatum* The fruit is a large dark blue bloomy drupe which forms an interesting contrast to the autumn coloration

Hardiness has been estimated zone 5a to 6 depending on the reference. It did survive the winters of 1976-79 in southern Illinois where temperatures were below 0°F for extended periods and fell to −20 to −28°F on occasions. Native dogwood and sweet gum were damaged in these winters.

Landscape characteristics include:

1. Lustrous dark green foliage
2. Very good to excellent flowering characteristics
3. Excellent, consistent fall coloration of very bright red to wine red, not dissimilar to Bradford Pear
4 Large bloomy blue fruit
5 Good bark characteristics
6. Tolerant of both natural wet and dry conditions

Cuttings root easily when taken as soft or maturing wood and treated with 2000-8000 ppm IBA in talc. Growth ceases after the cutting is taken and overwintering may be a problem

MODERATOR ALEXANDER: Ray Halward from the Royal Botanical Garden has a spirea to show us.

RAY HALWARD: *Spiraea nipponica* 'Halward's Silver' is a seedling selection. It has a good growing form that needs little

pruning and is a consistent performer The foliage is small and blue-green in color. The flowers are white and like the species.

MODERATOR KOLLER. The next speaker is Michael Dirr.

MICHAEL DIRR: The first plant is *Acer saccharum* subsp. *leucoderme*. The reason I mention this plant is because it is one of the few trees that gives us reliable orange or orange red fall color in the southern United States. It grows on dry areas in its native habitat and may be useful for city conditions. It is also small in stature 20-40 ft.

The next plant is a creamy white flower form of *Paulownia tomentosa* that a graduate student of mine found growing in Georgia The normal color is pale violet

MODERATOR KOLLER: The next speaker is David Longland from Garden in the Woods.

DAVID LONGLAND: *Boltonia asteroides* 'Snowbank' is a slower growing form of the species. The species is often 5 to 6 ft. and floppy in growth. The cultivar 'Snowbank' is 3 to 4 ft. high. The flowers are white, about 1 inch across and open in October for 3 weeks. This herbaceous perennial thrives under light shade to full sun in a moist, loamy soil with a pH of 4 to 5.5. Of special merit is the late blooming and prolific flower production that is supported on stiff stems

Ruellia ciliosa is a strong growing perennial native to the middle and southeastern U.S. This perennial is 8 to 12 inches tall, has a light green foliage and spreads moderately by self-sowing. The plant has an extensive root system. Flowering occurs in July and the color is light violet-blue This plant may be especially valuable for erosion control due to its extensive root system.

MODERATOR KOLLER: Harold Pellett has some plants to show us next.

HAROLD PELLETT: The reason I am showing you these plants is to make you aware of some hardier plants.

Berberis koreana, Korean Barberry, is a plant that has a lot of aesthetic qualities It's quite attractive when in flower with its numerous clusters of pendulant yellow flowers In late summer the plant is quite attractive when the fruit turns red These fruits hang on all winter. The plant also develops an excellent red fall foliage color. The plant does become leggy with age and responds well to pruning which is not much fun The plant also suckers freely so should be used where a mass effect is desired.

Tilia mongolica is a tree that's caught my attention. I haven't seen many trees but the ones we have and others I've seen are quite nice As lindens go it has a rather small leaf similar in size to *T cordata*. The bark is exfoliating adding an interesting fea-

ture to the tree. Unfortunately, I don't have a photo showing that characteristic. The branches are slightly pendulous and the crown is not quite as dense as that of littleleaf linden.

Populus tremula 'Erecta' — Swedish aspen. If one needs a columnar tree this is far superior to Lombardy or Bolleana poplar It is more resistant to canker and more uniform in growth. This photo was taken at the Morden Manitoba station. Our trees are much smaller but also quite uniform in growth. Unfortunately, the tree is difficult to propagate by stem cuttings. It can be grafted and I've heard that it will propagate easily by root cuttings if you have it on its own roots.

Prunus maackii — Amur cherry. If you're interested in winter bark color this is a real gem for its copper color smooth bark. The species is native in Manchuria and thus very cold hardy. The white flowers also can be fairly showy. Nurseries in our area are now utilizing this plant

Acer truncatum. This is one of the Asiatic maple species. I think we should look at this group of trees more closely. There are a number of species of *Acer* native in Japan, Korea and China that are small in stature From our midwinter hardiness testing it appears that many of these have considerable tolerance to cold temperatures in midwinter and may prove to be hardier than our references would indicate if we find the best source.

Acer ginnala. This is a selection of ginnala maple that we've been watching for its red fruit color in summer. I think selections could also be made of *Acer tataricum* that would add an extra dimension for midsummer fruit color.

Pinus cembra. In the last few years we've been observing our pine accessions quite closely for resistance to winter burn of the foliage Those that have shown the most resistance include *P. cembra, P. peuce, P. korainensis, P. flexilis* and *P. densiflora.* I'm a little reluctant to widely recommend these, however, as I'm not sure if the resistance is widespread in the species I've mentioned or if our accessions may happen to be from superior sources. Unfortuantely, I can't trace the source of our accessions back to their native site.

MODERATOR KOLLER: Our next speaker is Peter Girard.

PETER GIRARD: My first plant is *Acer griseum* 'Girard's Selection' that was selected from seed collected at Rochester Park. This plant has very fine bark, the foliage is bright scarlet in the fall and it has an upright growth habit.

Rhododendron 'Mt. St. Helen's' is a decidous azalea we have just named. The color is an orange and pink combination and the flowers occur in large clusters.

MODERATOR KOLLER: Jack Alexander has a plant he

would like to present.

JACK ALEXANDER: Sorbus *alnifolia*, the Korean mountain ash, has many unique characteristics and deserves wider distribution. The flowers are profuse and some of the largest in the mountain-ash group. The fruit is also attractive and red in color. The fruit display is generally alternate. In this species the leaves are simple. Winter interest is provided by gray bark similar to beech. *Sorbus alnifolia* is seed propagated and fruit from the earlier ripening fruit is sounder. Seeds germinate best when first given a warm stratification period followed by a cold stratification period

GARY KOLLER: I would now like to present *Schizophragma hydrangeoides*, the Japanese hydrangea-vine. This plant is often confused with *Hydrangea anomala* subsp. *petiolaris* This plant is very interesting because it flowers after the climbing hydrangea with white flowers that stand out from the wall about 18 inches. The white bracts remain white for 3-4 weeks It is like the climbing hydrangea in most respects, however, it is not as rank a growing plant. It is fully hardy at the Arnold Arboretum.

PLANTS AND PLACES IN TASMANIA

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Tasmania is the smallest state in the Australian Commonwealth with land area half the size of Alabama. It is an island state situated 43° south, which gives a very mild and even climate. In Hobart the temperature in winter occasionally drops to 32°F at night and averages 55°F during the day. In summer we have a few days over 100°F, but temperature averages 73°F. The main disadvantage is the high cost of transport to and from the mainland.

Tasmania landscape is very mountainous with some spectacular scenery. The west coast with its mountain ranges receives up to 180 inches of rain yearly, while in the eastern part the rainfall is down to about 20 inches.

In the 1800's Tasmania was an English penal colony. It is now a busy commercial state. Hobart, the capital, is famous for its yachting Copper is mined around Queenstown, and the sulfuric acid associated with the mining activity has killed much of the vegetation in the vicinity of the mines.

Our own nursery occupies about 20 acres. Two of our special interests are solar heating and tissue culture. We are using solar-heated water to warm our benches and have been very encouraged by our results. Ferns are our main tissue culture crop, especially the golden Boston fern, which is very popular in our country. We also propagate rex begonias, syngoniums, anthuriums and a few other herbaceous plants by tissue culture. Daphne is the only woody plant we are propagating in this way. There is some conifer propagation by the forestry commission, mostly of *Pinus radiata;* however, we are not propagating conifers.

In our fern tissue culture propagation we are careful to remove all agar by shaking the plants gently in warm water as soon as they are removed from the bottles. They are then planted in our regular peat:perlite mix and put onto the greenhouse bench with bottom heat. We maintain humidity by placing corrugated plastic sheets directly over the plants.

Native plants are very popular in Australian gardens, which makes much sense. In some cultivars a lot of hybridization is going on. Our conditions can be harsh, and introduced plants often fail to survive. One of our most popular families is that of the grevilleas, which are very hardy for our dry conditions. Some spectacular cultivars have been developed. These are some of the better ones:

Grevillea 'Poorinda Peter' — Evergreen tall shrub with new foliage covered in pink tips, light pink toothbrush flowers in spring

Grevillea 'Royal Mantle' — A beautiful prostrate cultivar

Grevillea 'Clearview David' — Evergreen small hardy grey-foliaged shrub with deep pink to red spider flowers in spring

Grevillea 'Crosbie Morrison' — Evergreen medium-growing shrub with grey foliage and deep red spider flowers in late winter and spring.

Grevillea juniperina (prostrata) — Evergreen medium shrub with dark green needle-like foliage and red or yellow flowers

Grevillea juniperina trinervis — Evergreen native flat-growing hardy plant that bears lovely greenish yellow flowers in spring

Grevillea 'Victoria' — Evergreen medium to tall shrub with narrow or broad leaves, deep red flowers in drooping clusters

Grevillea hookerana — Evergreen medium to tall shrub with narrow divided leaves and red toothbrush flowrs

Grevillea biternata — Evergreen prostrate to medium shrub, divided narrow leaves, lacy white flowers in spring. Useful ground cover.

Another popular family is that of the acacia or wattle. These come in all types from large trees to dwarf shrubs. Their main flowering time is late winter.

Acacia baileyana — Evergreen small tree with silver-grey fern-like foliage, golden yellow flowers in winter Cootamundra wattle

Acacia drummondii — Evergreen small to medium shrub with small fern-like leaves, yellow rod flowers in spring

Acacia boormanii — Evergreen medium to tall shrub, narrow foliage, small yellow flowers in profusion, early spring.

Other popular natives are:

Leptospermums or tea trees — Evergreen medium compact shrubs with flowers from white to pink and red, mainly flowering in spring

Banksias — *Banksia ericafolia* — Evergreen tall shrub with small leaves, large cones of amber to reddish flowers in spring

Callistemons or bottle brushes — *Callistemon citrinus* — Evergreen medium shrub with clusters of pinkish-red bottlebrush flowers at ends of branches There is a great deal of breeding being done in this group

Mintbushes — *Prostanthera ovalifolia* — Evergreen tall shrub, narrow-oval leaves, mauve-purple flowers in profusion in spring.

Prostanthera rotundifolia — Evergreen small to tall shrub, rounded small leaves, lilac flowers in spring

Hardenbergia violacea — Native evergreen climber with twining stems, lilac pea-shaped flowers in spring. 'Happy Wanderer' cultivar has been especially popular.

Boronia megastigma — One of Australia's most popular flowers Small evergreen shrub, fine foliage, yellow sweetly-scented flowers in early spring.

Boronia *heterophylla* — Small shrub with unusual prostrate, small leaves, blue flowers in spring This makes a very showy ground cover.

Lithospermum humifusum — Small shrub with unusual prostrate, small leaves, blue flowers in spring This makes a very showy ground cover

Hibbertia procumbens — Evergreen small shrub, narrow leaves, yellow flowers.

A new hybrid golden diosma, *Diosma* 'Eureka' — Evergreen shrub, fine golden foliage with white flowers.

Eriostemon myopotoides — Wax flowers — Evergreen medium shrub with light green fragrant leaves, pink buds and white flowers winter and spring.

Pimelea rosea — Evergreen small to medium shrub, glossy green leaves, heads of bright pink flowers in spring.

These plants are drought-hardy but are sensitive to high summer humidity. They grow successfully where the climate is favorable for calistemon. Seed for most of the non-hybrids is available from seed dealers in Australia.

FLOWERING TREES OF AUSTRALIA

MARCUS A. PETERSEN
Dannebrog Nurseries Pty. Ltd
51 Braun Street
Deagon, Queensland, Australia

The climatic regions in Australia vary considerably, from tropical wet in the north through sub-tropical, to temperate in the south, with isolated areas of intermediate climates. There are small areas of alpine climates in our snowy mountains, an area of Mediterranean type climate, and much desert in the interior of the continent. Consequently, Australia has a wide range of plants with differing requirements, though many have adapted to such an extent that they grow in a variety of climatic regions and conditions. We also have some that are very specific in their requirements, and many of these have not been brought into cultivation successfully at this stage.

Because of the extremely wide range of Australian flowering trees, I will consider only a small selection found in my state of Queensland and give you some idea of the climatic range in which they can be grown.

Acacia longifolia, Mimosaceae. Flowering: Bright yellow racemes in spring. Height: Approx. 3-5 m, variable. Habitat: Dry hillsides, well-drained soils. Climatic tolerance: Annual rainfall 500 to 1000 mm; temperature range 0 to 35°C. Propagation: by seed. A very graceful small tree.

Acacia peringusta, Mimosaceae. Flowering: Pale yellow in winter and early spring. Height: 3-5m. Habitat: Variable but often along banks of watercourses. Climatic tolerance: Annual rainfall 300 to 1400 mm, temperature range 5 to 35°C. Propagation: By seed. A very attractive small garden tree with lacy foliage.

Acacia podalyriifolia, Mimosaceae. Queensland silver wattle — Flowering: Bright yellow in winter. Height: 305 m. Habitat: Dry exposed well-drained hillsides in coastal areas, soils derived from sandstone in inland areas. Climatic tolerance: Annual rainfall 600 to 1000 mm, temperature range 0 to 35°C. Propagation: By seed.

Anopterus macleayanue, Escalloniaceae. Flowering: Spring to summer. Height: 15 m in nature, usually only 5 m in cultivation. Habitat: Rainforest, well-

A new hybrid golden diosma, *Diosma* 'Eureka' — Evergreen shrub, fine golden foliage with white flowers.

Eriostemon myopotoides — Wax flowers — Evergreen medium shrub with light green fragrant leaves, pink buds and white flowers winter and spring.

Pimelea rosea — Evergreen small to medium shrub, glossy green leaves, heads of bright pink flowers in spring.

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Anopterus macleayanue, Escalloniaceae. Flowering: Spring to summer. Height: 15 m in nature, usually only 5 m in cultivation. Habitat: Rainforest, well-

drained soil rich in humus Climatic tolerance Annual rainfall 1600 to 2000 mm, temperature range 0 to 30°C Frost tender when small Propagation· By seed and cuttings

Archontophoenix alexandrae, Palmae Alexandra palm Flowering Variable in winter, white to mauve unisexual in pendulous panicles followed by attractive red globular fruits in early summer Height 20 to 30 m Climatic tolerance Annual rainfall 800 to 2000 mm, temperature range 5 to 35°C Habitat Tropical and subtropical rainforest Propagation· By seed An attractive house plant in young stage of growth

Archontophoenix cunninghamiana, Palmae Bangalow palm Very similar to the Alexandra palm Easily identified in the young stage of growth by the foliage Alexandra has a silver reverse to the leaf while the Bangalow is green

Baeckia virgata, Myrtaceae Flowering White, similar to leptospermum in summer Height 3 to 5 m Habitat Variable, open forest areas and soil types Climatic tolerance Annual rainfall 300 to 1600 mm, temperature range 0 to 35°C Propagation By seed or cuttings

Banksia integrifolia, Proteaceae Flowering Creamy brushes up to 26 cm long and 10 cm in diameter, mainly autumn and winter Height 5 to 15 m Habitat Sandy coastal soils, open forest of coastal plains and ranges Climatic tolerance Annual rainfall 750 tp 2000 mm, temperature range 0 to 35°C Propagation By seed

Brachychiton acerifolius, Sterculiaceae Illawarra flame tree Flowering Bright red late spring and early summer Height 40 m in nature, usually about 10 m in cultivation Habitat Rainforest Climatic tolerance Annual rainfall 1000 to 3000 mm, temperature range 0 to 35°C Propagation By seed Reliable garden subject in coastal eastern Australia

Callistemon 'Gawler hybrid,' Myrtaceae Flowering Red bottlebrush-like flowers up to 26 cm in length and about 5 cm in diameter Height 3 to 5 m Habitat A wide range of soil types Climatic tolerance Annual rainfall 800 to 1500 mm, temperature range 0 to 35°C Propagation Usually by cuttings to maintain type A very desirable garden plant

Callistemon polandii, Myrtaceae Flowering Red bottlebrush-type flowers with golden-tipped stamens in spring Height 3 to 6 m Habitat Fairly wide range of soil types Climatic tolerance Annual rainfall 1000 to 2000 mm, temperature range 0 to 35°C Propagation Usually by cuttings, variable from seed

Callistemon salignus, Myrtaceae Willow bottlebrush Flowering Spring to summer Usually cream, but there are other color variations to pink Height 2 to 10 m, quite variable in form Habitat Swamps and watercourses Climatic tolerance Annual rainfall 600 to 2000 mm, temperature range 0 to 35°C Propagation By seed or cuttings Quite good in cultivation, many cultivars

Castanospermum australe, Leguminosae Papilionaceae Black bean, Moreton Bay chestnut Flowering Spring to summer Height 40 m in nature but usually about 12 m in cultivation Habitat Rainforests near streams and on coastal flats Climatic tolerance Annual rainfall 1000 to 2000 mm, temperature range 5 to 40°C Propagation By seed or cuttings, makes quite a good container plant, and has potential as a Bonsai plant Fruits are poisonous

Ceratopetalum gummiferum, Cunoniaceae New South Wales Christmas bush Flowering White in spring followed by colorful red bracts in summer Height Up to 7 m Habitat Open forest Climatic tolerance Annual rainfall 1000 to 1600 mm, temperature range 0 to 35°C Propagation Usually by seed but can be grown from cuttings Good garden subject in well-drained soils

Doryanthes palmeri, Amaryllidaceae Spear lily Flowering· Long red drooping spikes in spring Height 2 to 3 m Habitat Cliffs and rocky hillsides in and near rain forests, usually above 600 m elevation Climatic tolerance Annual

rainfall 1600 to 2500 mm, temperature range 0 to 35°C Propagation By seed or division Seedlings take up to ten years to flower

Eucalyptus ptychocarpa, Myrtaceae Swamp bloodwood Flowering Mainly summer and autumn, many color forms Height Up to 18 m Habitat. Open forests often along water courses Climatic tolerance Annual rainfall 100 to 1600 mm, temperature range 10 to 35°C Propagation. By seed A very spectacular tree

Eucalyptus torquata, Myrtaceae Flowering Usually pinky orange in spring and summer There are some different color forms Height 5 to 15 m Habitat Open forest, usually sandy well-drained soils Climatic tolerance Annual rainfall 500 to 1600 mm, temperature range 0 to 35°C Propagation By seed A very attractive small to medium tree

Evodia elleryana, Rutaceae Flowering In summer, color forms red to pink or mauve Height Up to 30 m, but usually smaller in cultivation Habitat Rainforest Climatic tolerance Annual rainfall 1000 to 2000 mm, temperature range 10 to 35°C Propagation By seed Seedlings have been known to flower in three years, but seedlings are frost-tender

Grevillea banksii, Proteaceae Red silky oak or Banks' grevillea Flowering Usually in spring but in cultivation almost always some flower Color varies from red to pink and white Height 5 to 9 m There are also different forms with varying heights These include a 1-m low spreading type, a 2- to 3-m shrubby form and a slender erect small tree Habitat Stony ridges, gravelly clays to sandy soils It prefers acid conditions Climatic tolerance Annual rainfall 1000 to 1600 mm, temperature range 5 to 30°C Does best in areas not subject to severe frost Propagation. By seed and by cuttings A very attractive group

Grevillea glauca gibbosa (Syn Grevillea glauca), Proteaceae. Flowering· In winter Height 5 to 8 m Variable from coastal lowlands to higher altitudes of 500 m or so in a variety of soil types Climatic tolerance Annual rainfall 500 to 2000 mm, temperature range 10 to 35°C Propagation By seed

Grevillea pinnatifida, Proteaceae White oak Flowering In late spring and early summer Height Up to 25 m in nature but rarely more than 8 m in cultivation Habitat Rainforest Climatic tolerance Annual rainfall 2000 to 3000 mm falling throughout the year, temperature range 10 to 30°C Propagation By seed Quite a desirable tree for sub-tropical to tropical regions

Grevillea robusta, Proteaceae Silky oak Flowering Spring to early summer Yellowish-orange Height Up to 40 m in nature, usually smaller in cultivation Habitat Rainforest Climatic tolerance. Annual rainfall 600 to 1400 mm, temperature range 0 to 30°C Propagation By seed A very attractive tree

Grevillea 'Coochin Hill', Proteaceae Flowering: creamy yellow in winter and spring Height 3 to 6 m, erect Habitat Sandy or stony soil in open forest Climatic tolerance Annual rainfall 700 to 900 mm, mainly during summer, temperature range 10 to 30°C Propagation. By seed or cuttings

Hibiscus heterophyllus, Malvaceae Native rosella Flowering: Yellow up to 12 cm in diameter, during summer and autumn mainly. Height Up to 5 m Habitat Open forest often in rocky well-drained areas. Climatic tolerance Annual rainfall 600 to 1400 mm, temperature range 10 to 35°C Propagation· By seed or cuttings

Hymenosporum flavum, Pittosporaceae. Native frangipanni Flowering. Light cream when young, darkening to yellow with age, up to 5 cm in diameter; spring Height Variable up to 20 m in nature, usually smaller in cultivation. Habitat Rainforest, deep moist loams Climatic tolerance Annual rainfall 1000 to 2000 mm, temperature range 0 to 35°C Frost tender when young Propagation. Usually by seed Very attractive as a garden specimen tree

Jagera pseudorhus, Sapindaceae Foam bark, fern top, pink tamarind Flowering Minute flowers followed by attractive orange colored fruits Height

Up to 12 m Habitat Hillside slopes, light loam to stony clay Climatic tolerance Annual rainfall 800 to 2000 mm, temperature range 10 to 35°C Frost tender when young Propagation. Usually by seed A very attractive small tree

Melaleuca decora, Myrtaceae Flowering· White, loose spikes 1 to 6 cm long and 1 5 cm in diameter in summer Height Up to 8 m Habitat Coastal lowlands, heath and open forests in areas of poor drainage Climatic tolerance Annual rainfall 700 to 1400 mm, temperature range 0 to 35°C Very young plants are frost tender Propagation By seed or cuttings

Melaleuca symphyocarpa, Myrtaceae Flowering Usually reddish globular heads 3 to 4 cm in diameter but color variants of yellow and orange Height Up to 6 m Habitat Open forests on sandy soils associated with watercourses Climatic tolerance Annual rainfall 1000 to 2500 mm, temperature range 5 to 40°C Propagation By seed or cuttings

Oreocallis wickhanii, Proteaceae Pink silky oak, satin oak, red silky oak Flowering Profuse, bright red, 5 cm long on a 4 cm stalklet in spring to early summer Height Up to 27 m in nature but usually about 10 m in cultivation Habitat Rainforest Climatic tolerance Annual rainfall 1000 to 2000 mm, temperature range 0 to 35°C Propagation Usually by seed but can be grown by cuttings A truly magnificent tree

Randia fitzalanii, Rubiaceae Yellow mangosteen Flowering Spring followed by summer fruits Height About 6 m. Habitat Open rainforest along watercourses Climatic tolerance Annual rainfall 1000 to 2000 mm, temperature range 10 to 35°C Propagation Easy from seed

Stenocarpus sinuatus, Proteaceae Wheel of fire tree Flowering Profuse in summer and autumn Bright red umbels of 6 to 20, up to 10 cm across Height. Up to 30 m in nature but usually about 10 m in cultivation Habitat Rainforest Climatic tolerance Annual rainfall 1000 to 2000 mm, temperature range 10 to 35°C Propagation By seed

Szygium coolminianum, Myrtaceae, Syn Eugenia coolminiana Blue lilly pilly Flowering White with numerous stamens about 1 cm in diameter followed by very colorful berries in spring and summer Height Up to 10 m Habitat Rainforest from low to high altitudes and along creek banks Climatic tolerance. Annual rainfall 1000 to 1500 mm, temperature range 5 to 35°C Propagation. From seed after removing outer flesh.

Syzgium jambolana, Myrtaceae, Syn Eugenia mooreii Coolamin, robby, rose apple Flowering Usually red but sometimes pink, rarely white, followed by large globular creamy-white fruit approximately 5 cm in diameter Height. About 40 m in nature but usually about 10 m in cultivation. Climatic tolerance· Annual rainfall about 1000 to 1500 mm, temperature range 5 to 35°C Habitat Rainforest along rivers and creek banks Propagation By seed after removing outer flesh

Syzygium luehmannii, Myrtaceae Syn *Eugenia luehmannii* and *E parvifolia* Small leaf, water gum, cherry alder Flowers Cream to white, small panicles in summer Height Up to 30 m in nature but usually about 9 m in cultivation in subtropical regions Habitat· Rainforest along rivers and creek banks from low to relatively high altitudes Climatic tolerance Annual rainfall 1000 to 1500 mm, temperature range 5 to 40°C Propagation From seed Tree bears heavy crop of berries after flowering Flesh must be removed before sowing Can also be grown from cuttings New growth is an attractive bright pinky bronze

Brachychiton rupestris, Sterculiaceae Bottle tree Flowering Fairly insignificant, but this is a most unusual tree Height Up to 20 25 m Habitat Usually found in drier inland areas Climatic tolerance. Annual rainfall 400 to 1000 mm, temperature range 0 to 40°C Propagation. By seed A most unusual novelty tree

Xanthorrhoea australis, Xanthorrhoeaceae Grass tree, black boy, yacca, kangaroo tail Flowering Small white to cream, borne in large numbers along a long spike up to 3 m long and approximately 6 cm or more in diameter, in late spring

Height 7 m including flower spike Habitat: Open forest, mountainous areas, usually in volcanic soil but also can be found in poor sandy soils in heath lands Climatic tolerance Annual rainfall 350 to 1500 mm, temperature range 10 to 35°C Propagation Quite easy from seed

These are just a few of the magnificent plants that Australia is endowed with. I trust that this gives some idea of the wide range of material that is available to us. The following references will enable further investigation of Australian flora.

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THE COLD STORAGE OF DORMANT MATERIAL

A.T. WOOD

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General Considerations. I would suggest that there are two reasons for using cold storage. Both of these are tools of management: (1) to avoid the closed season when lifting cannot be undertaken, (2) to extend the planting and lining-out season by holding material dormant and prolonging the optimum condition for planting and establishment. Our experience is wholly with this second reason, and I propose to discuss our successes and failures at some length.

In North America and on the Continental mainland of Europe, it is most necessary to avoid the closed season by placing plants in store. However, the British Isles, with their maritime climate is usually open for most of the lifting season and the necessity to lift in the autumn and hold throughout the season seldom arises. However, where stock is required for grading and dispatch of plants to more favorable climates or stock for bench grafting is required, there is no alternative to the early lift. The main problems in the storage of this material are linked to the proper hardening-off before lifting. Die-back and disease particularly become a problem when foliage is taken into store and buds are not hardened-off. Plants that are under stress in store could

Height 7 m including flower spike Habitat: Open forest, mountainous areas, usually in volcanic soil but also can be found in poor sandy soils in heath lands Climatic tolerance Annual rainfall 350 to 1500 mm, temperature range 10 to 35°C Propagation Quite easy from seed

These are just a few of the magnificent plants that Australia is endowed with. I trust that this gives some idea of the wide range of material that is available to us. The following references will enable further investigation of Australian flora.

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THE COLD STORAGE OF DORMANT MATERIAL

A.T. WOOD

Oakover Nurseries Ltd.

Potters Corner, Ashford, Kent, England

General Considerations. I would suggest that there are two reasons for using cold storage. Both of these are tools of management: (1) to avoid the closed season when lifting cannot be undertaken, (2) to extend the planting and lining-out season by holding material dormant and prolonging the optimum condition for planting and establishment. Our experience is wholly with this second reason, and I propose to discuss our successes and failures at some length.

In North America and on the Continental mainland of Europe, it is most necessary to avoid the closed season by placing plants in store. However, the British Isles, with their maritime climate is usually open for most of the lifting season and the necessity to lift in the autumn and hold throughout the season seldom arises. However, where stock is required for grading and dispatch of plants to more favorable climates or stock for bench grafting is required, there is no alternative to the early lift. The main problems in the storage of this material are linked to the proper hardening-off before lifting. Die-back and disease particularly become a problem when foliage is taken into store and buds are not hardened-off. Plants that are under stress in store could

result in die-back and poor establishment in the following season. We have had some experience of Continental material arriving in this condition though we have not ourselves lifted before the plants are fully dormant.

Our Method. We considered the reasons for which we might use storage. We wanted a storage facility, but it is expensive. Since we felt we could not afford to own one, we have worked out a very satisfactory arrangement for hiring a fruit store during its unused season. Apples are stored until around Christmas. When they are sold, the owner thoroughly cleans the room and we then begin to store our plant materials. We use cold storage for the holding of most of our lining-out stock. Off-grades and selected plants can be held in cold store and the double handling of heeling-in avoided. The stock can wait until the land is in good condition for planting and sufficient labor is available. The use of a cold store in this way is most certainly an aid to management in the growing of our seedling and transplanted crop.

There are some hazards, but in the main I consider that the practice is advantageous. The prime advantage is that material is planted in the optimum condition for establishment, and one is the master of the situation. We are all only too well aware of the sinking feeling that accompanies an early spring when good stock is flushing and deteriorating by the day, and stresses of labor requirement and soil conditions do not permit a speedy enough planting. This situation of panic and dilemma can be largely avoided; the peace of mind that comes with having plant material in cold store is worth a lot. Labor requirements can be planned effectively and planting conditions can be considered when plants can be kept dormant. The selling season can be extended, particularly where there is a long established relationship with the customer and cold stored material can be offered. The avoidance of heeling-in operations and the double handling, which is costly of labor, is also a worthy consideration.

Some nurseries use cold-stored material for open-ground planting and accompany this with cold-storage wagons to transport throughout the country. This is primarily where stock grown in the south is travelling into Scotland. Ancillary considerations such as adequate supply of water and irrigation equipment are essential where dormant stock that would normally be planted in April is coming out of store to establish in late May and June. The effect on other nursery operations and equipment are also to be considered. When labor and tractors are being used to plant in June, other jobs may be affected. These basic considerations are essential before entering into a program of cold-store planting.

Types of Store Available. There are basically two types, direct or indirect (jacketed stores). Direct stores are cheaper to construct and are virtually an insulated box with a coolant circulated through a convertor through which air is directed and circulated within the store. This presents some problem with humidity control, but the problem can be overcome by the use of polythene bags to protect the plants.

In a jacketed store cool air is circulated outside an inner liner within an outside insulated wall. In double-wall store plants can be kept bare-root with minimum humidity control. Purpose-built stores for holding dormant plant material should be of this type.

Our Experience and Method of Storage. We have built up the quantity of plant material stored over the past few years to a point where we now hire a large fruit store from the New Year onwards. This is a direct store with a capacity of 100 T of fruit. The temperature can be held very accurately at 32 to 34°F. All our plants are bagged in 250 gauge polythene, not sealed, and packed in bins which can be handled with a pallet loader. Frequent splashes of water on the concrete floor of the store enable us to hold the humidity. The amount of water used is determined by the degree of icing on the exchanger.

Our seedlings are lifted and graded in the normal way throughout the dormant season. Plants for re-lining or potting are root-trimmed. It is most important that this trimming be done before storage. Root development does take place during storage, and this development would be lost in late trimming. The seedlings are bagged loosely and sprayed with Elvaron (Euparen M, tolyfluanid, Bayer AG) to reduce *Botrytis cinerea*. The bags are labelled and numbered and the totals and dates of entries are recorded. Duration of the storage with regular inspections can be 4 to 6 months. Scionwood collected in January could be stored until June or July. Dr. Brian Howard at East Malling Research Station has done this.

We plan our input and output from the store to correspond with the natural flush of the plants. For instance *Crataegus* plants are taken out early while late flushing plants such as *Juglans* are left until last. During 1979 we had a cool damp spring with very easy establishment from store. In 1980, however, we had a dry April and May and the value of our irrigation equipment was put fully to the test. One of the useful bonuses of our cold storage was that we were able, with confidence, to stop planting, use our irrigation to apply residual herbicides and in this way ensure excellent weed control in what was for most growers in the United Kingdom a very difficult year. Our seed-sowing operation could also be given priority; we were able to take labor away

from planting to spray herbicides and insecticides. In this way the quality of our work was maintained at a high level even though the planting operation was extended far beyond our expectations.

One of the problems was that we normally use our labor for potting and containerizing after the planting operation. Since potting was delayed, some plants did not make up to a satisfactory size for autumn sales. In addition, if one extends the planting season too long, when do you take your holidays! The technique must be planned into the whole of the nursery operations for the year and, if this is done, cold storage of dormant material can only be a useful adjunct to the nursery.

In conclusion, I would say that cold storage, if treated well, is good practice It needs a good back-up facility; we could not carry on our present level of production without this storage. The cost is high, but if you are able to hire for a short period then the facility is most economical and, in our case, preferable to owning our own storage facilities.

STORAGE OF DORMANT PLANTS AT MOUNTAIN CREEK NURSERY

MIKE HALLUM

Mountain Creek Nursery Co.
Route 5, Box 170
McMinnville, Tennessee 37110

Proper storage of dormant plants is a necessity, whether the plants are to be shipped to customers or used as lining-out stock in the nursery. For this reason careful attention must be paid to controlling the environment of the area where dormant plants are stored.

At Mountain Creek Nursery we have attempted to develop a system whereby we can efficiently process dormant stock and still maintain plants in such a way as to insure maximum survival after transplanting. Our bare-root stock is dug soon after it becomes dormant and immediately transferred to our grading, baleing and packaging building. Here the stock is graded and, depending on our needs, packaged, baled or boxed for shipment — or in the case of our lining-out stock, moved to our heeling area until planting time.

We also buy a quantity of bare-root plants from other growers We maintain a cold-storage facility for storage of some of this stock, especially if we anticipate delays in spring planting. Inside the building this material is heeled-in in sand or old sawdust, or

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the roots are packed in straw, depending on cultivar and size of the plants.

The 200- and 250-ft refrigerated area occupies the lower level of the building. It is insulated with styrofoam, and two units are used for cooling, one primarily for backup. Water from the units may accumulate and cause puddling. We spray the walls and floor with 50% Clorox solution to help avoid the development of disease problems that can easily occur under damp conditions. The floor is concrete and is thick enough that we can drive right into the storage area for loading and unloading.

It is always difficult to dig dogwood as early as it should be in the spring. Successful reestablishment is never easy later in the season. This past year we dug a small amount of our stock as soon as it became dormant and heeled the plants out in sand in the refrigerated building. We had very good results but want to repeat our trial before adopting this method as our usual procedure for dogwood.

We recently constructed a storage and shipping building for the storage of balled and burlapped stock, which enables us to take care of the stock during the time between digging and shipping. We are able to control the moisture level of the stock, and we do not have to heel-in the plants because the temperature inside is such that freezing rarely occurs. Another important advantage to this type of facility is that it allows for all-weather shipping, which is especially important during unusually wet or cold periods.

In conclusion, we have found that attention to the factors which determine success or failure in storage of dormant plants is vitally important if one desires to maintain a reputation of producing good quality plants.

STORAGE OF BARE-ROOT DECIDUOUS PLANTS

BEN DAVIS II

Hill Country Nurseries, Inc.
Tahlequah, Oklahoma 74464

The storage methods which will be covered here have all been used by Ozark Nurseries Company, with whom I have been associated for 21 years. Ozark Nurseries produces a broad line of field-grown deciduous ornamental and fruit plants, as well as coniferous evergreens. The firm is located at Tahlequah, Oklahoma, which is in the northeastern part of the state, in U.S.D.A. plant hardiness zone 7a. According to the U.S.D.A. map, the low

the roots are packed in straw, depending on cultivar and size of the plants.

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winter temperatures in this zone range from 0 to +10 degrees Fahrenheit However, we usually experience a few days in which the temperature drops to −5 degrees F. and, in some winters, to −10 or −15 degrees F.

The proper storage of bare-root deciduous plants enables the nurseryman to keep them in a viable, dormant condition through the fall, winter, and spring in such a manner that they are readily available for order-filling and shipment when and as needed.

There are three basic storage methods which accomplish this goal with varying degrees of success They are; (1) heeling outdoors in beds or trenches, (2) placing inside an air-cooled or common storage building, and (3) storing inside a mechanically refrigerated building.

No matter which method is used, it is important that plants be in good condition when they are placed in storage. This requires that they be grown with the best possible cultural practices so that they are vigorous and healthy and will have the proper levels of stored carbohydrates If plants are dug before they are fully dormant, they will not have a chance to store the proper levels of these essentials in their stems and main root system This lack of nutrients will cause them to store poorly and, in extreme cases, to die while in storage. *Prunus* species are especially susceptible to these conditions, while *Malus* species will generally tolerate a great deal of abuse Other species of deciduous woody plants with which we have had experience generally fall somewhere between these two extremes.

HEELING OUTDOORS

The principal advantage in heeling outdoors is that there is no large capital expenditure required Beds or trenches can be dug by hand or with a small loader or dozer The plant bundles are then stood in the trench and the roots are covered with soil by hand, after which they are thoroughly watered in When plants are needed to fill an order, the required number are merely pulled from the bed. Ozark Nurseries stored plants in this manner from its founding in 1895 until 1947, when the first air-cooled storage building was built.

There are several disadvantages to heeling outdoors. First, it requires a large amount of labor, something that is not always easy to get now. Second, if the weather is inclement or the ground is frozen, plants can not be removed from the heel bed. Third, if spring comes early, the plants will break dormancy, precluding further shipments. This can be a big drawback if one has northern customers who request late spring shipment. Nevertheless, if one has a strong back and not much money to get

started, heel beds are a legitimate way to store plants.

AIR-COOLED STORAGE

An air-cooled or common storage building is a big improvement over heel beds. The air-cooled storage depends on mother nature to help maintain plants in a dormant condition. Such a building can be above ground, with thick masonry or insulated walls, or it may be partially sunken into the ground, so as to allow soil to be mounded up around the outside walls. In either case, the building has a dirt floor. The dirt floor helps to keep the building cooler than outside temperatures in the fall, and warmer than outside temperatures when it is very cold. The dirt floor also helps to maintain proper humidity if it is managed properly. Our Yankee friends call this type of structure a "root cellar."

When the inside temperature is warmer than desired and the outside temperature is colder, cold air is drawn in through openings in the walls by use of fans until the desired temperature is reached inside. Care must be taken that outside air is not so cold as to freeze plants stacked near the air-intake openings. Grills should be kept over the openings to prevent the entry of rodents. When warm weather occurs, the inside temperature can be kept cool by keeping the building as tightly closed as possible As spring approaches, it becomes more and more important to take advantage of every cool night to chill the storage in anticipation of warm days.

An air-cooled storage gives the nurseryman more control over his bare-root inventory than he would have with heel beds, and it works fairly well in northern climates. However, the further south one goes, the less satisfactory it becomes. At Ozark Nurseries we used air-cooled storage from 1947 until 1974 fairly successfully; but in years when spring came early, we had difficulty in keeping plants dormant until our northern shipping was concluded.

In using air-cooled storage, it is important to water carefully to maintain the proper humidity. This requires daily watering of the walls, floor, and the plant stacks. If the storage is kept too wet or too dry, plants will be lost. It is best to train one individual for this job and then check on that person often to see that the watering is properly done. Each building will have certain spots that tend to stay too wet or too dry, and these spots must receive special attention. It is best to keep the humidity at approximately 80%. It is not practical to keep the humidity much higher than this with hand watering because you then begin to get wet spots in the storage which can cause rot. A well-managed air-cooled storage is a very good way to store plants until one can afford to take the next step to refrigerated storage.

REFRIGERATED STORAGE

The very best bare-root storage, and the most expensive, is the mechanically refrigerated and humidified storage. At Ozark Nurseries, we converted our air-cooled storage to this type in 1974. Finding the right equipment and a knowledgeable firm to install it was quite an educational experience. Most firms that sell and install refrigeration equipment do not understand the application of this equipment to the storage of nursery plants.

In our case, investigation revealed that installing the recommended insulation on the floors, walls, and ceilings of all of our storage buildings would cost more than the refrigeration equipment itself. Since the outside walls on most of our buildings were 18 inches thick and of double wall construction, we felt that we could install refrigeration capacity slightly larger than would normally be installed and cool the storage satisfactorily without the additional insulation. While this approach would use more electricity than normal, we felt that it would take many years for the cost of additional electricity to equal the cost of the insulation recommended. This was especially true when we considered that the refrigeration would only be operated during the coldest six months of the year.

We contacted four suppliers of equipment for quotations on the job. Two of these went strictly "by the book" and did not give what we felt was adequate consideration to cost effectiveness. One supplier flatly told us that a system could not be installed that would work under the conditions we proposed. Fortunately, the fourth supplier that we contacted took a common-sense approach and offered us a plan that was both workable and that fell within our budget for the project.

One very important point that needs to be made is that the cooling coils should have electric defrosting. Under the conditions of high humidity and low temperature, the units do not have adequate time to defrost naturally before they need to come on again to maintain the desired temperature.

In conjunction with the refrigeration system, we installed automatic humidifying equipment. Mechanical refrigeration removes large amounts of moisture from the storage, and this moisture must be replaced. After consulting with several other nurseries having this equipment, we decided on a system in which air and water are mixed in special nozzles to create water vapor. This avoids the problems that free water can cause in the storage and allows us to maintain the humidity at up to 95 percent if we wish.

The system which we use supplies water and air to the nozzles in two separate lines, both of which are under pressure. Timers are used to open and close solenoid valves in the air and

water lines. This system also has humidistats which override the timers. The humidistats keep the timers from switching on the valves when sufficient humidity has been attained.

We purchased the components for the humidifying system and installed it ourselves. In the process we made some mistakes which I will pass on to you so that you won't have to repeat them First, don't try to save money by using plastic pipe. Plastic pipe sags, even in very short spans, allowing air bubbles to become trapped in the water lines. These air bubbles tend to act as a cushion, holding open the check balls on the nozzles, so that when the water shuts off, there is a constant drip from the nozzles. It is better to use galvanized steel pipe, taking care to get each run of pipe level so that air does not get trapped in the water lines.

The second mistake that we made was in trying to run this system with well water Water tends to absorb air from the water system's pressure tank, contributing to the problem of air in the water lines Fortunately, we had city water available, so we hooked our system to city water. If your water system has a pressure tank, it is better to use a float tank and gravity system for the water lines that supply the humidifying nozzles.

Our system has been in operation for six years and, on the whole, we have been very pleased with it. I would like to give special credit to Rod Bailey of Bailey Nurseries in Saint Paul, Minnesota, who was very helpful in sharing their experiences with cold storage equipment. While some of our rooms do not stay as cold as we would like in the late spring, we can hold our temperature in the range of +35 to +45°F until very late in the spring. This is the performance that our equipment supplier promised, and we find it adequate for our needs.

When converting an air-cooled storage to mechanical refrigeration and humidification, certain new problems in storage management are encountered which need to be considered. It is important to keep accurate readings on the humidity and to regulate the humidifying system carefully. If the humidity is too high, mold becomes a problem. Most of the wall-mounted humidity gauges that are on the market are not very accurate and do not last very long. A sling psychrometer is essential to get accurate humidity readings. The humidity should be checked once each day in each storage room and adjustments made on the humidity controls if necessary Ohio State University recommends keeping the humidity below 90% and the temperatures as cold as possible to retard the growth of mold-causing fungi (2).

It is also vital to control fungus organisms in the storage with a regular spray program. Ohio State University recommends a combination of 2 lbs of Terrachlor (PCNB, Olin Corp.) 75% WP,

and 2 lbs of captan 50% WP in 100 gal of water, sprayed on the plants (2). We have found that spraying every week to 10 days, rotating among Benlate (benomyl, duPont), Botran (DCNA, Tuco) and captan, works well for us. Benlate 50% WP is applied at the rate of 1½ lbs per 100 gal of water. The captan 50% WP and Botran 75% WP are applied at the rate of 2 lbs per 100 gal of water. The higher the humidity and the warmer the storage, the more often spraying must be done. We apply the spray to the plant stacks and to the floor, walls, and ceiling of the building.

FALL STORAGE PREPARATION

Before the storage is used in the fall, two steps must be taken to get it ready. First, sprinklers are set up and run for about two weeks to get the floor thoroughly wet. Sprinkling is discontinued about one week before storage use is expected to begin in order to allow the surface mud to dry so that the floor is thoroughly damp, but not muddy. The damp floor is a major factor in helping to regulate the humidity.

Second, the storage is thoroughly sprayed to disinfect it. We spray the floors, walls, and all of the plant racks with Citcop 4E (a copper resinate, Cities Service) at the rate of 3 qts per 100 gal of water The ceilings of our buildings, which are aluminum and steel, are sprayed with captan 50% WP at the rate of 2 lbs per 100 gal of water. The reason for not using Citcop on the ceilings is to avoid excessive corrosion.

CONCLUSION

There are two publications on storage which I would like to mention. The first is, "Proceedings of the Woody Ornamentals Winter Storage Symposium, December, 1977" (3). This is available from Ohio State University, 2001 Fyffe Court, Columbus, Ohio, 43210. The cost is $5.00 and checks should be made payable to, Storage Symposium. The second publication is, "Storage of Nursery Stock" by J.P. Mahlstede and W.E. Fletcher, Iowa State University, Ames, Iowa (1). This publication was printed by the American Association of Nurserymen in 1960. It is now out of print, but the Horticultural Research Institute is cooperating with Dr. Mahlstede to publish a new edition. HRI expects this to be available in late 1981. Inquiries can be directed to the Horticultural Research Institute, 230 Southern Building, Washington, DC 20005.

If you are contemplating construction of a bare-root storage facility, you should do the following:

(1) Get the above mentioned publications and study them. They have a lot of valuable information that will enable you to make more knowledgeable decisions.

(2) Talk to fellow nurserymen about what they are using and their experiences with their facilities. You can learn from their experiences, but you should keep in mind your climate and the particular functions desired for your own facility. Not everyone's operation will be the same.

(3) Shop at least three suppliers of the equipment you will need. Listen to their proposals and try to determine which one seems the most knowledgeable about your particular application. The lowest bid is not always the cheapest in the long-run. You should also consider the supplier's ability to service the equipment after it is installed.

Some of the things that I have mentioned here might seem elementary or self-evident. However, I have found that when I take the elementary things for granted that is usually when I get into trouble. Careful attention to seemingly minor details is important when making such a large investment.

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1 Mahlstede, J P and W E Fletcher 1960. *Storage of Nursery Stock.* Washington, American Association of Nurserymen 62 p.

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STORAGE OF DORMANT PLANTS

HUGH STEAVENSON

Forrest Keeling Nursery
Elsberry, Missouri 63343

Forrest Keeling Nursery is located in northeast Missouri on the hills above the Mississippi River, almost equi-distant between the Gulf and the Canadian border. Here normal minimum temperatures range between 0° and −10°F, but recent cold winters have seen temperatures plunge as low as −25°F.

We are in-ground or field growers. Therefore, we do not have the over-wintering problems facing northern container growers. However, we do grow several million deciduous seedlings, liners, and other trees and shrubs harvested bare-root. These are mostly dug in the late fall or early winter when they are dormant and just before the ground freezes. This material requires most careful and attentive storage to retain its viability until it is ultimately planted by the customer the following spring.

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In addition to this bare-root stock, we grow trees, shrubs, and evergreens, which are harvested balled and burlapped (B&B) or, mostly, balled and potted in fiber pots (B&P). A considerable portion of this balled material is harvested in the fall for early spring shipment and thus requires protective storage.

SIMPLE STORAGE METHODS

Storage can be simple or sophisticated. Some of the simplest procedures, if done with adequate care, can be quite as effective as the more involved methods. For example, good heel-in storage or bare-root stock may be unsurpassed. However, the heel-in method is seldom suited to modern-scale production.

I once heard a true story of a chap in his early years as nursery grower. He had shown a buyer his field of shrubs and they stopped under a huge spreading oak to consummate their deal.

"Where is your packing shed?" the buyer asked. "You are standing in the middle of it," the young nurseryman replied.

Now, you can picture stacks of desiccated shrubs handled in such fashion. On the contrary, the nurseryman in question dug to order, did a good job of protecting his stock with tarps and other cover from lifting to packing and delivered entirely acceptable, viable plant material. Obviously, this rather primitive procedure would not be practicable for any but small operations.

BARE-ROOT HARVEST

We do have a number of mail-order and other cusotmers that must have limited quantities of bare-root stock for fall shipment in October. This is really too early to harvest and we dig only such quantities at this time as are essential to fill these limited orders. Otherwise we do no digging until stock is well-defoliated and obviously dormant.

Our first killing frost occurs about October 20, but we do not reach a low of 15°F until about November 10. Then several species and cultivars become defoliated and we can start harvesting. Although a number of defoliants have been placed on the market and various leaf-stripping devices have been introduced, we have no interest in them as we want our plants to become dormant naturally before harvest can proceed.

The period between thorough dormancy and ground freeze-up is indeed limited. We have to go flat out to complete our fall harvest in this brief period. We pretty much put all hands, including our female grading crew, on this chore. Tender hands do not relish pulling frosty shrubs. But we emphasize that unless the plants are in storage there will be no grading work through the winter.

Incidentally, recent introductions in harvesting equipment have substantially speeded this operation. The Grayco modified potato digger pulled with a hydrostat tractor is a real boon where soil conditions are right. We seem to tear up two or three of the Edgedall bed lifters each season, but they are handy devices. The new, one-row, off-set lifter gives good performance with modest power investment.

During drying weather we keep a tank truck in the field to water down this bare-root material as it is dug and placed in pallet crates. A fungicide, such as Benlate (benomyl, duPont) is aded to the water to reduce likelihood of mold once stock is in storage. The crates are loaded on wagons, tarped down for protection against sun and wind, and hauled the short distance of a mile, or less, to the storage buildings

BARE-ROOT STORAGE

Our new storage houses, each with 200,000 plus cu. ft. capacity, are sufficiently insulated with 4 inches of styrofoam so that subfreezing temperatures can be prevented without supplemental heating. We believe it is very important to insulate adequately due to the escalating costs of energy. Before any plants are brought in for storage the houses are thoroughly cleaned and drenched throughout with copper sulfate solution to eliminate residual mold spores. Of course copper sulfate canot be used on plants. With our control of temperature, humidity and, especially, ventilation (described below) *Botrytis* or other mold build-up is usually not a severe problem. But we do use a spray of Benlate, Botran (DCNA, Tuco) or other fungicidal spray as added protection.

The storage houses are equipped with Bahnson humidifiers, which can create a dense fog in the buildings. We also have intake and exhaust fans that can be thermostatically controlled with outdoor-indoor thermometers; however, we find manual control of the buildings more satisfactory. As I live on the premises, one of my chores is to check the 10:00 pm T.V. weather report At night, of course, the temperature normally drops while the humidity often rises to or near the saturation point. Wind direction and velocity are also taken into account. Usually this combination of present and forecast conditions will call for maximum or substantial ventilation of the buildings, particularly during the fall and early spring.

Plants, even thoroughly dormant deciduous plants, give off an amazing amount of heat through respiration. When the storage buildings are stacked to the ceiling with pallets of such plants, it takes either a tremendous amount of outside cold air or refrigeration to cool the stored plants to near the freezing point. We do

have a substantial portion of the buildings refrigerated; however, using outside cold air for cooling is a lot less expensive than cooling by refrigeration. Furthermore, most refrigeration systems, excepting double-jacketed cold storage or counterparts, are dehydrators.

On a night when the outside temperature may drop as low as 15°F with high humidity and not much wind, we find we can open the storage doors wide and still not get the inside temperature to the freezing point. Of course the doors are sealed at sunup, normally the coldest hour of the day.

Thus, with careful manipulation of humidistats and air circulation, near ideal conditions can be maintained in good common storage until the warmer days of spring approach. Now it is increasingly difficult to catch subfreezing nights to cool the buildings when plants have "awakened" from their winter rest and are ready to grow. Hopefully, by this time, most stock has been shipped. What hasn't must go into the refrigerated section where temperature can be held near the freezing point.

Some nurserymen store stock under refrigeration in a frozen state slightly below the freezing point, or about 28°F. This seems to work fine with no injury to tops or roots of hardy plants. Under our conditions with grading and shifting of stock proceeding at a hurry-up pace all winter, such storage would present a bit of a problem, not to mention the extra energy cost involved.

Something else — there are indications that the "shock" to certain species taken from subfreezing storage to sudden warm weather planting conditions is harmful to the growth cycle. It would be helpful to have more study on this point.

Storage of this dormant bare-root stock really continues through the packing and shipping process and even after it reaches the customer. We use a heavy telescoping poly-lined corrugated fiber shipping case which generally travels in good condition regardless of shipping method. The insulated walls of the case protect against all but severe or sustained freezing and the polyliners seal against dehydration of the stock. We do add a bit of sphagnum moss or cedar tow for window dressing, but find it necessary to add a card to point out the function of the poly film. It is amazing, after all these years, that some customers still do not understand the function of a polyethelene shield in protecting plants against drying.

STORAGE OF BALLED OR POTTED STOCK

The use of poly-covered quonsets for over-wintering container or balled stock is so commonplace and universal as to need little elaboration. With our in-ground production we are not faced with the over-wintering problem attending the northern

container growers. But we do need to store and protect some stock for two reasons: (a) to have a quantity of stock ready to go for early spring shipment and (2) to protect tops of certain cultivars from winter burn and have the plants in a good, salable condition with the onset of spring weather. The evergreen euonymus is an example of plants in the latter category. Indeed, most evergreens — conifers, as well as broad-leaved plants have a brighter, more appealing color in early spring coming from proper storage than from the field.

We find the "double tent" system economical and quite satisfactory for this type of storage. We used a standard 30 ft wide quonset with a gravel (aggregate) floor and a grade that assures excellent water drainage as well as air drainage when ends or doors are open. The gravel floor also is a good conductor of soil heat to the potted plants. Plants are balled and placed in fiber pots in mid-to-late fall. Before double-stacking in the house, one edge of a sheet of 4 mil clear poly, 16 ft wide, is fastened to each inner side of the house baseboards. The houses are filled with stock by Thanksgiving or the first of December. Now the top cover of 4 mil white poly, 40 ft wide, is stretched in place over the house and firmly fastened to the baseboards. Ends will remain open a bit longer — until about December 10 to provide ventilation. Now the house ends are closed, the potted plants thoroughly soaked and the poly blankets pulled over the plants and fastened to the edges of the center aisle.

With this "double tent," or blanket within a tent, adequate protection is provided in our most severe weather. We have found temperatures only slightly below freezing when subzero temperatures and high winds prevailed outside. With this system we can see no need for using supplemental heat, the more expensive microfoam blanket, nor for laying plants flat or taking other cumbersome steps. Stored plants need little, if any, attention through the winter. The final soaking before covering with the blanket usually suffices until spring. Of course, if gale winds rip off inadequately secured house covers, or if snow or ice loads collapse the house, all bets are off. We do provide extra bracing against snow loads and try to secure our covers against any expected winds. The combination of a white copolymer tent with clear poly blanket over the plants also prevents advanced spring growth so that the stock can be delivered for display on sales yards at proper time in a fresh but still dormant condition.

PROPAGATION OF DECIDUOUS AZALEAS

H.C. NIENHUYS

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We will concentrate on a deviation from the standard method of propagating deciduous azaleas. The azaleas we are discussing were selected by the late Lionel de Rothschild at his estate in Exbury, England. This is why they are commonly called Exbury azaleas. The great value of Mr. de Rothschild's breeding program was that he never kept a plant unless it was superior to the parents. Only the very best was kept for further crossings and all the rest immediately destroyed. The Exbury's are noted for their exceptionally beautiful colors. The Knap Hill group was developed by Knap Hill Nursery. They are hybrids of *R. molle*, *R. calendulaceum*, *R. occidentale* and *R. arborescens*.

Today most of the propagators take cuttings from stockplants that are growing under normal conditions. Usually this is done in the beginning of June after the plants have flowered and developed new shoots. Our method was developed by Adrian Knuttel about 1965, now operating as Knuttel Nursery in Windsor Locks, Connecticut. It differs in the time when the cuttings are taken. During late fall the stock plants are placed in a greenhouse that is not yet covered with plastic. By this time the plants have lost their leaves, which helps reduce the incidence of disease. After the plants have gone through a good cold spell, the greenhouse is covered with plastic, usually in early January. The plants have to thaw out, which takes about two weeks with temperatures ranging from just above freezing to 45°F by the end of the second week. The temperature is then gradually pushed up to 70°F by the beginning of March. Following this forcing method, the plants will flower between the 20th and the end of March. Taking the cuttings can start about April 10. All cuttings should be taken by the end of April. If any cuttings are taken later, they will have insufficient summer growing time before dormancy.

The stock plants are regularly fertilized every 10 to 14 days after March 1 with 1 lb of Ra-pid-Gro in 50 gal of water. If black June weevils are a problem, drench the soil with 1 pint 75% chlordane in 50 gal of water.

The right conditions for the cuttings is very important. Suitable new shoots will be about 6 inches long, slightly firm, just about to snap when bent double. They still should be hairy. If the hairs are gone, it is too late to take cuttings.

The cuttings will go limp very easily so the taking of cuttings should be done in the early morning. They should be kept cool, even by putting them in a cooler if necessary to keep them crisp.

We take only the amount of material that can be processed by noon that day. The cuttings are stripped, leaving four leaves. The tip is removed, cuttings are wounded, treated with hormone, and stuck in beds of pure Canadian peat. The peat should be pre-moistened and rubbed by hand to loosen it. Long fibers and roughage should be removed. It should be fine and powdery when put into the bed. German peat would be better but has become too expensive and, the last two years, unavailable.

We start with 1% or 0.8% of IBA powder (indole-3-butyric acid) and cut it down to 0.4% IBA with Benlate (benomyl) and a pinch of boric acid. We combine 2 heaping tablespoons IBA powder, 2 heaping tablespoons Benlate, and a very small amount of boric acid powder. In fact, we use only an amount about the width of the lead of a pencil that will stay on the tip of a knife. The soil temperature is kept at 73°F with hot air under the bench. The peat must not become too soggy. When using in-ground propagation houses, a misting system will not be necessary at that time of year. The watering then can be done by a mist nozzle at the end of a watering hose. In regular above-ground greenhouses, a misting system will be required.

After four weeks, when rooting has started, the cuttings are fertilized weekly with 1 tablespoon of 23-19-17, (Ra-pid-Gro Co., Dansville, NY) per 3 gal of water. Ra-pid-Gro, approximately 250 ppm, is used because it contains small amounts of the minor elements that are essential for the growing of Exbury azaleas. In order to prevent *Botrytis*, which is a common problem, the cuttings are treated once a week with Dithane M-22 (maneb, Rohm & Haas) Special with zinc, 1 heaping tablespoon per gal using a knapsack sprayer.

In 6 to 8 weeks, the cuttings are rooted and transplanting starts directly into 2-gallon containers in houses which are shaded for 1 to 2 weeks depending on the outside heat.

We are now at the end of June and the young plants have the summer to grow outside. They have plenty of time to produce new growth before longer nights and dormancy. If the plants do not get enough time to produce the new growth, they usually fail to break the following spring. Well-rooted cuttings that fail to break before dormancy starts will not break next spring. They will either die or stand all the next summer without breaking and only will break the following spring. That is the reason why many growers have to resort to artificial lighting.

The above described method of propagation involves heat, for example, for 300 stock plants for 3 months. The old method requires artificial lighting for the 10,000 rooted cuttings for 3 months plus the prevention of freezing all winter. The only way it is practical to provide lighting for that many cuttings is to keep

them in flats or small pots. In no way will they grow as well as in the 2-gallon containers, which will be salable as budded plants next fall.

By taking the cuttings two months earlier than the general rule, we get two month's summer growth more, enough to get them into a regular growing cycle. They will go dormant normally, do not need artificial lighting, and are salable one year earlier.

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PROPAGATION OF RABBITEYE BLUEBERRIES

JACK FINCH

Finch Blueberry Nursery

Bailey, North Carolina 27807

Why grow rabbiteye blueberries? There are many reasons. They are excellent for homeowners since they not only provide fruit but can serve as screens or as ornamental plantings to provide fall color. With the correct choice of cultivars the homeowner or pick-your-own grower can have an 8 to 10 week bearing period.

Our operation is different from the usual in that we do everything in the open. Our main reason for choosing this method of operation is that the plants do not require the constant attention that is necessary if they are either in the greenhouse or in containers outside. Even our rooting of cuttings is done outside. Although we have been very happy about this system, we may in the future expand to include greenhouse and container production as well.

Our soil is a well-drained Norfolk sandy loam. We are, therefore, able to put our propagation beds right on top of the native soil. We have used a 1:1 peat:sand medium and have found it quite satisfactory. We have experimented with various other media, including pinebark, sawdust, and other materials. Some of these have also given very good results and, as costs

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change, we may use the materials that we find are the most economical. Almost any medium is satisfactory if handled properly.

Since we have found it necessary to leave our plants unattended at various times, it has been important for us to have a dependable system for controlling the water supply. Our control system is our main innovation. We tried the electronic leaf but found that our water was too pure to conduct the current. Although that difficulty could be overcome, we found a second surprising problem at another time when we discovered the control was not operating. An insect lodged between the electrodes completely prevented the control's operation. We then substituted a system in which the control was operated by the weight of the water that accumulated on a screen fastened to a lever arm. The system worked very well except for the fact that the wind caused rapid fluctuations in the movement of the lever arm. If the screen and the control mechanism were protected from the wind, the water accumulation no longer matched that on the leaves of the plants since the screen was in a different environment.

When I purchase meat in the market, I observed that the scale fluctuated once or twice, then came to rest. I discovered that a mechanism called a dash pot is incorporated in the scale. This is simply a cylinder containing oil and a plunger that moderates the movement of the scale. In order to accomplish the effect of the dash bar, I filled a 6-gallon bucket with water and suspended an 8-inch basket from the lever arm into the water. This, of course, is on the opposite end of the lever arm from the screen. The screen can be made of any light material that will collect water and yet dry fairly quickly. We use a light-weight cheese cloth wrapped around a 7 in by 43 in cylinder constructed of 2 in by 4 in welded wire fence material. A mercury switch is fastened to the lever arm directly above the pivot point. The back part of the assembly is protected from water with a fiberglass panel. It is important when constructing a control of this type to have the lever arm on a sharp pivot point, as this will increase sensitivity. (Figure 1)

We take cuttings beginning middle to late June when the first flush is hard enough to break. Cuttings are taken from nursery and stock plants maintained on 6- by 12-foot spacing. It would be possible to take cuttings 8 months out of the year except for the fact that we also need time to handle other nursery operations. Most important of all, we must market the plants. Our mix is prepared by using a manure spreader so placed in beds spaced to allow driving through them. We provide 75% shade during the rooting process. We leave the cuttings in the rooting

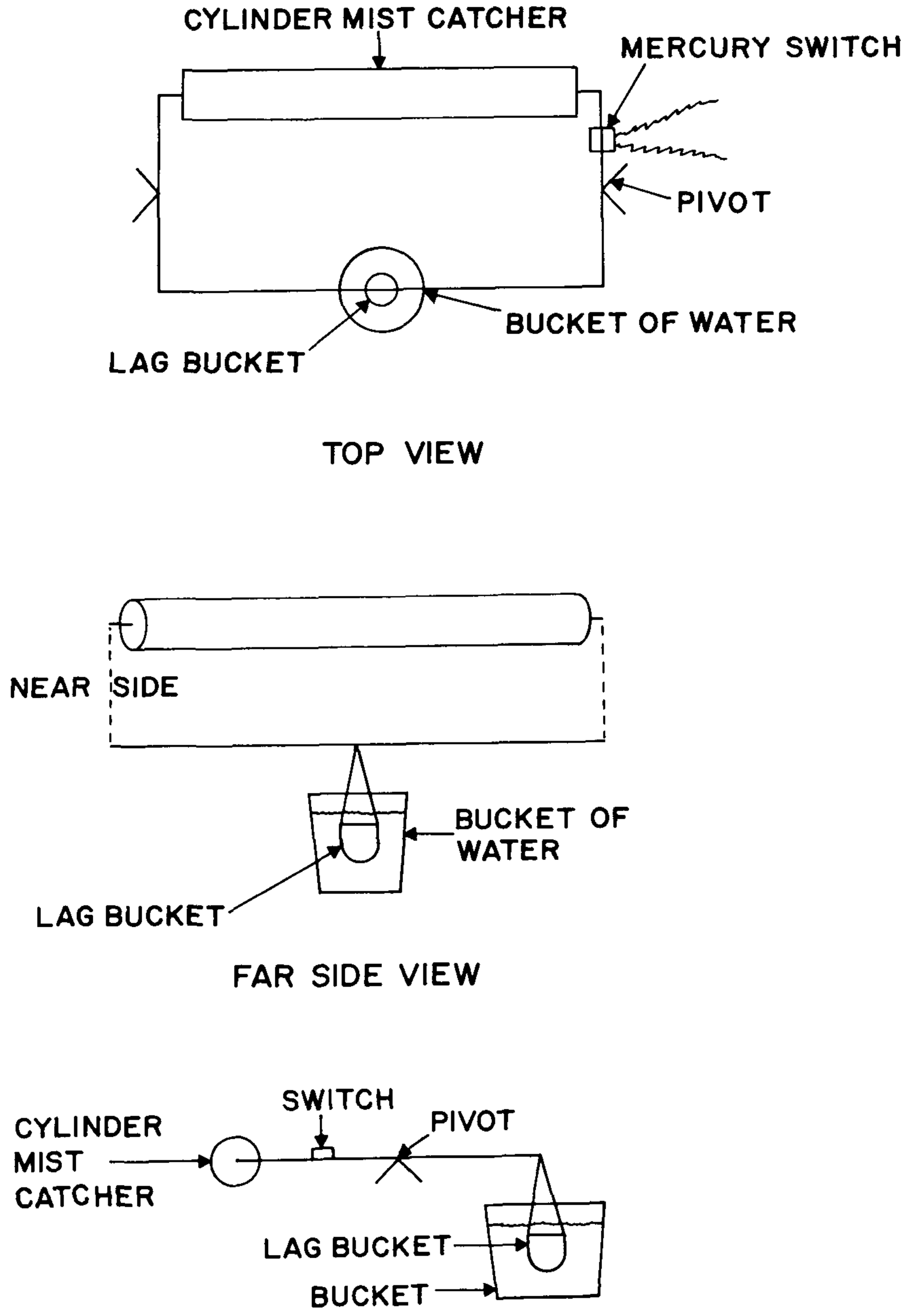

Figure 1. Water control mechanisms for mist showing lag bucket used to reduce fluctuations (Drawings by Stephanie Knopp, Athens, Georgia)

bed at least 2 years but can still have salable plants at the end of 3 years if for some reasons we do not move them sooner.

When plants are moved to the field, we level and compact the beds, then set the plants right on top of the soil through old sawdust placed to a depth of 5 to 6 inches on top of the soil. We use Rain Bird sprinklers in the propagation bed with a ⅛ inch or $^5/_{32}$ inch orifice with adjustable screw spreader. The Rain Bird sprinkler must have 50 to 60 psi pressure to operate and mist properly, although we ordinarily have no problem with water pressure, we do maintain a booster pump We also have a diesel-powered back-up for the propagation and irrigation system.

Our entire operation also includes the propagation of a few muscadine grapes. In addition, we have a pick-your-own operation that includes peaches, blueberries and grapes. We find that the sequence works out well as the peaches can be picked first, followed by the blueberries and then the grapes. Our propagation and plant sales are done at other times of the year.

We feel that satisfied customers are important. We encourage them to buy at least two cultivars of blueberries for good crop set.

MICROMAX — MICRONUTRIENTS FOR IMPROVED PLANT GROWTH[1]

CARL E. WHITCOMB, ALLAN STORJOHANN, and WILLIAM D. WARDE[2]

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Abstract: A 3^5 factorial set of treatment combinations were developed to study the effects of iron, manganese, copper, boron, and zinc on growth and development of container nursery stock A computer was used to select ⅓ of the treatment combinations for the study and data analysis

Interactions were noted between iron and copper, iron and manganese, and copper and boron Plant growth and quality increased or decreased as the micronutrient ratios shifted This study revealed that the ratio among the micronutrients was a more important consideration than the rate of a particular micronutrient

In 1957, Matkin, Chandler, and Baker (3) wrote "since micronutrients are required in such minute amounts by plants and are natural components of peat, soil, fertilizer, and water, it is improbable that a soil mix would develop micronutrient deficien-

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[1] Journal Series #3929 of the Oklahoma Agr. Experiment Station

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cies." Since that time, many studies have been conducted to improve the physical and chemical aspects of container growing (2,4,5,6,7,8). In general, with each improvement in the conditions in the container, i.e. total pore space, air space, carbon: nitrogen ratio, and media structure and components, improved plant growth and quality has been achieved. Likewise, with each advancement in the understanding of container nutrition growth has improved. These improvements in plant growth and quality have come in steps as successive limiting factors have been removed. There are probably many more limiting factors to be discovered and removed before maximum plant growth in containers can be achieved.

In 1969, Whitcomb (7) showed that as N,P,K rates were increased, higher rates of Perk (a micronutrient fertilizer manufactured by Wilson & Toomer Fertilizer Company, Jacksonville, FL) also had to be increased to achieve maximum growth with the physical and cultural conditions imposed on the plants at that time.

METHODS AND MATERIALS

Based on these studies and observations of plant responses to micronutrients in many nursery situations, a 3^5 factorial study with 2 replications for each species was begun in 1977. Iron, manganese, copper, boron, and zinc were used at rates which were thought to be near optimum. Each rate of each micronutrient studied was reduced by ½, and doubled to achieve the 3 levels of each element in the study. Since a complete 3^5 factorial has 243 treatment combinations, a computer was used to select the 81 treatment combinations likely to provide the most useful data to understand the micronutrient interactions.

Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and molybdenum were held constant for all treatments. N, P, K were supplied by Osmocote 18-6-12, Ca and Mg by dolomite, and molybdenum by sodium molybdate at rates of 14 lbs, 8 lbs, and 0.09g cu yd. (8.3 and 4.7 kg/m^3 and 1.17g/m^3) respectively. The growing medium was a mix of 2 parts ground pine bark, 1 part Canadian peat, and 1 part washed concrete sand. Micronutrient sources were ferrous sulfate, manganese sulfate, zinc sulfate, copper sulfate, and sodium borate.

Recently rooted liners of *Pyracantha* 'Watereri' (*P. coccinea* 'Lalandii × *P. crenulata* 'Watereri') were planted into one gallon (3.8l) containers on May 12, 1977. Plants were grown in full sun under sprinkler irrigation for 5 months and evaluated for height, fresh top weight, and stem caliper.

One-year old *Rhododendron* 'Hinodegiri' were planted on June 9, 1977 and were grown until July 12, 1978 under 30%

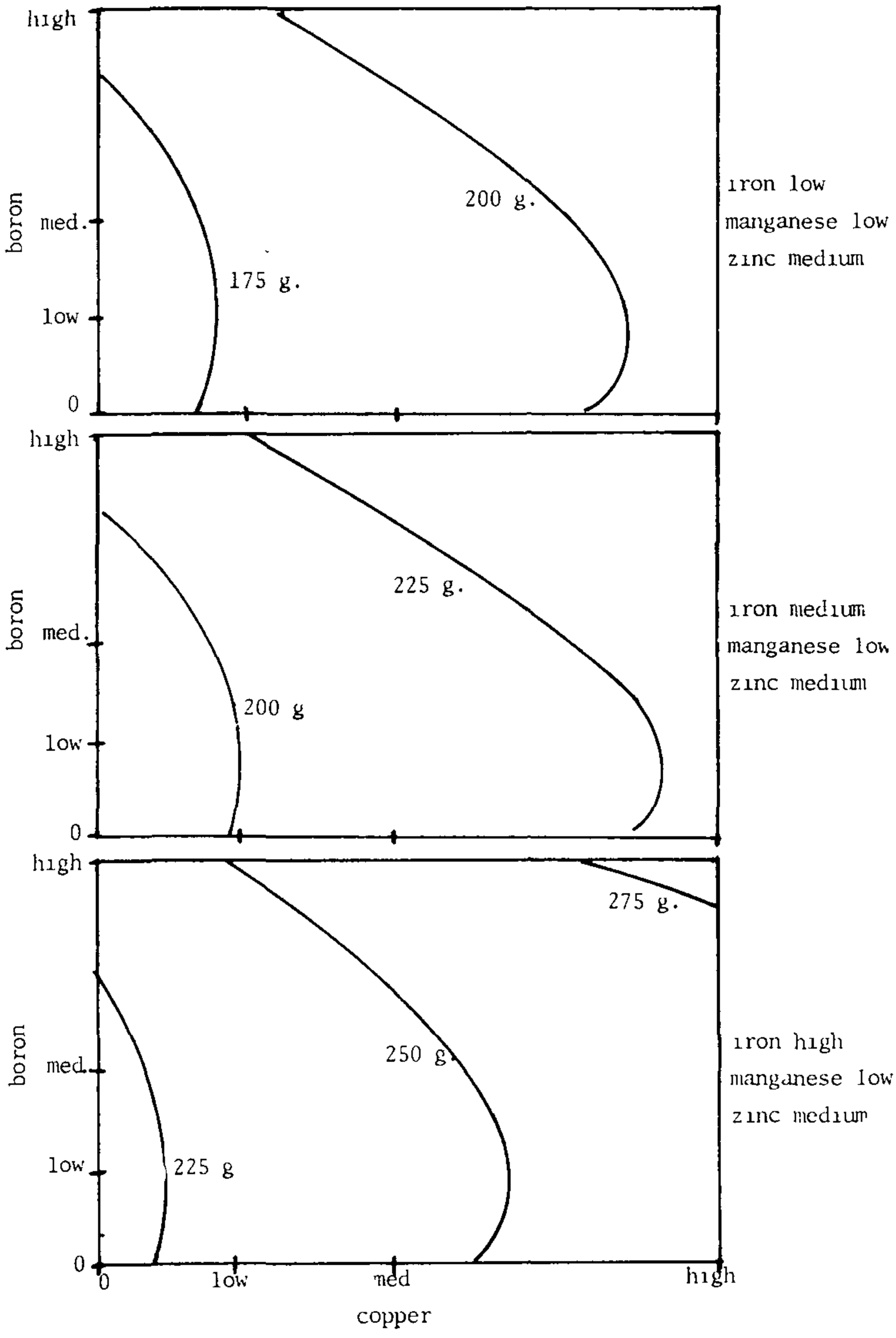

Figure 1. Fresh top weight (grams) response of pyracantha to combinations of micronutrients in containers· low iron (top), medium iron (center), high iron (bottom) The greatest top weight was achieved when the high boron and high copper levels were used with the high iron

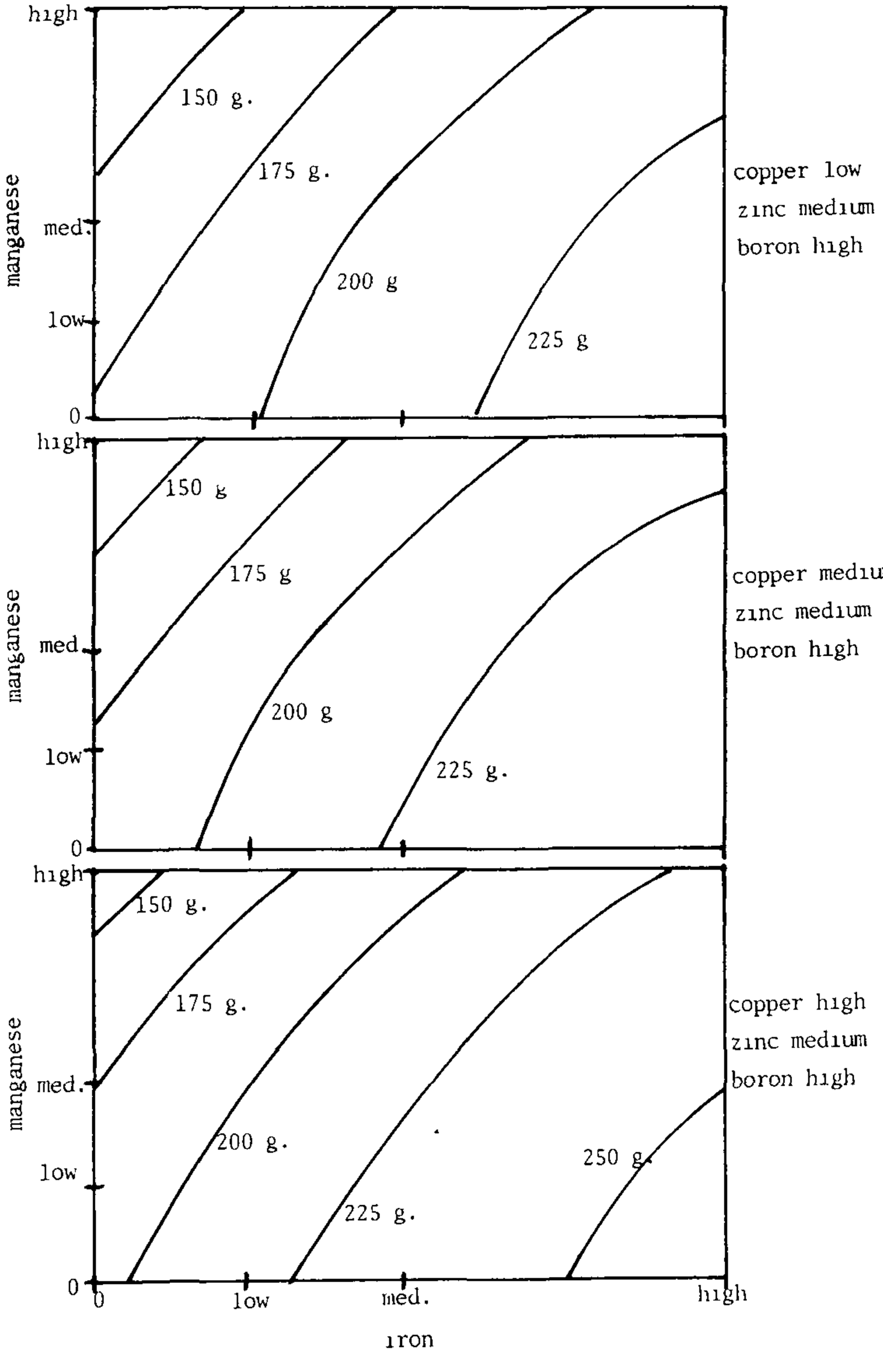

Figure 2. Fresh top weight (grams) response of pyracantha to combinations of micronutrients in containers, low copper (top), medium copper (center), and high copper (bottom) The iron and manganese levels gave about the same top weight response at the low and medium level of copper, however, top weight increased when the copper was increased to the highest level

shade. The azaleas were evaluated for visual grade twice, once in February following leaf drop by some treatments and at termination and for flowering and fresh top weight.

RESULTS AND DISCUSSION

Interactions between iron and copper, iron and manganese, and copper and boron were significant for both pyracantha and azalea. Response of the two species to the various micronutrient levels was similar, thus only two of the response surfaces of pyracantha are presented. Computer plotted response surfaces showed that fresh top weight of pyracantha increased significantly as iron increased from the low to the high rate but the maximum top weight was achieved (275 grams) only when the high boron and high copper rates were also present and manganese was at the low rate (Figure 1). Zinc had little influence on plant response, suggesting that even the lowest rate used was sufficient. Fresh top weight of pyracantha was similar for the low and medium rates of copper with the various combinations of iron and manganese; however, top weight increased with the combination of the high rate of copper and iron, low rate of manganese and the high rate of boron (Figure 2). In all cases, maximum growth was obtained only when manganese was at the low rate. This is in agreement with Epstein (1) who noted that high rates of manganese can cause iron deficiencies due to a competition for functional sites on iron binding compounds. Maximum plant growth response to copper was obtained only when boron was at the highest rate tested.

Figure 3. Azaleas grown with high rates of copper and boron and low manganese and high iron (left), medium iron (center), and low iron (right). Leaf retention and color and flower numbers and overall plant quality were increased by increased rates of iron, but only if manganese, boron, and copper were at the correct level.

Visual plant response was usually more distinct on azaleas than pyracantha in that few foliar deficiency symptoms developed on the pyracantha. During the winter azaleas with high iron and copper and low manganese rates held their leaves and retained a dark green foliage color, whereas plants with high rates of manganese dropped many leaves. Visual plant quality increased as iron level increased and manganese was low and copper and boron rates were high (Figure 3).

The proportions of micronutrients suggested by these data were used to make an experimental micronutrient fertilizer. After considerable testing and some further adjustments in the micronutrient sources and ratios, the commercial product, 'Micromax'[3], was developed.

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[3] Manufactured and distributed by Sierra Chemical Company, 1001 Yosemite Drive, Milpitas, California 95035 under a license agreement with Oklahoma State University .

EFFECT OF MICRONUTRIENT NUTRITION DURING PROPAGATION ON CONTAINER PLANT PRODUCTION[1]

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As work progresses, effects of micronutrient fertilizers on all aspects of plant growth becomes more clear. Preliminary studies with several species of shrubs suggest that the micronutrient level in the parent plant, and/or increased plant growth and vigor associated with improved parent-plant micronutrient nutrition affects rooting of cuttings and subsequent growth. Taking cuttings from the existing container crop is expanding as container production continues to expand across states in the sun belt. Many growers feel it is impractical to maintain stock plants specifically for cuttings. Stock plants can be reduced or eliminated without sacrificing plant quality, if the performance of cuttings taken from existing container stock can be improved.

The objectives of this study were: 1) to determine the optimum rate of a micronutrient fertilizer for container nursery stock, and 2) to determine if the level of micronutrients provided to the parent plant influences the rooting and subsequent growth of cuttings.

METHODS AND MATERIALS

Experiment 1: On April 3, 1978, an experiment was set up to compare plant growth in a micronutrient-free growing medium with plant growth in a medium containing 4, 6, and 8 lbs/cu yd of Esmigran[3] and 1, 2 and 3 lbs of experimental O.S.U. micronutrients (now sold as Micromax[4]). The growing medium was 2 parts ground pine bark, 1 part peat, and 1 part sand by volume, with 14 lbs 18-5-11 Osmocote, 8 lbs dolomite, and 1½ lbs 0-46-0 per cu yd incorporated. Test species were Hetz Japanese holly, *Ilex crenata* 'Hetzii'; Hetzii juniper, *Juniperus chinensis* 'Hetzii', and Fashion azaleas, *Rhododendron* 'Fashion'. Azaleas and hollies were grown under 30% saran shade while the junipers were in full sun. Watering was by overhead sprinklers, approximately one inch every other day during the growing season.

Cuttings were taken from the holly and junipers and stuck in a 1:1 peat and perlite mixture with 9 lbs of 18-6-12 Osmocote added per cubic yard and placed under intermittent mist on

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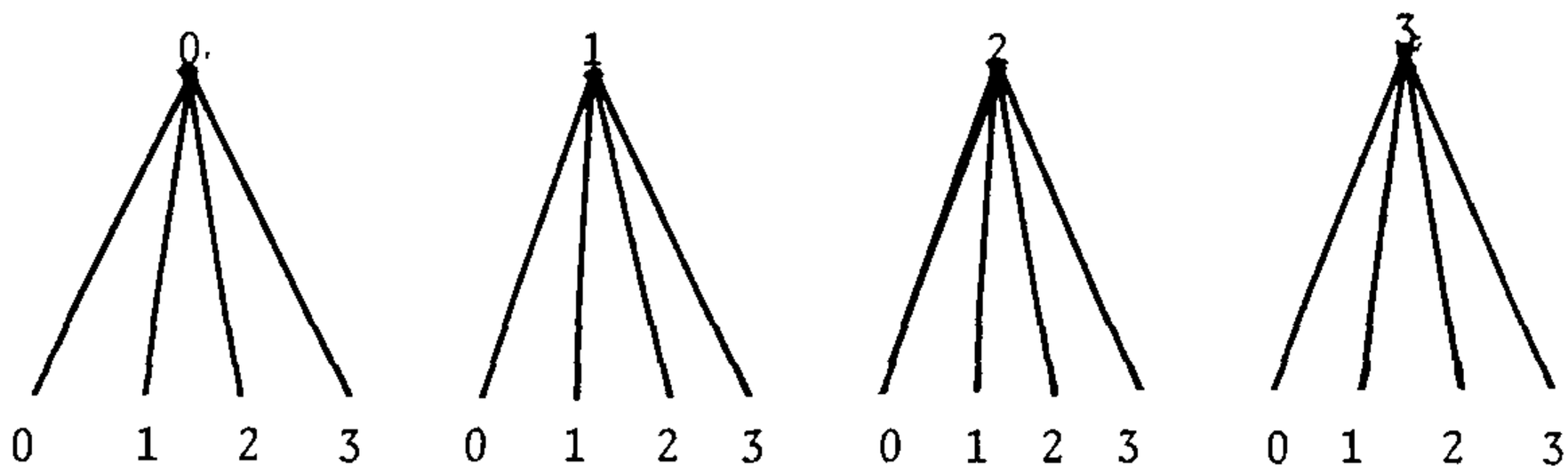
[1] Journal Series #3924 of the Oklahoma Agricultural Experiment Station
[2] Professor of Horticulture
[3] A micronutrient fertilizer manufactured by Mallinckroadt Chemical Co, St Louis, Missouri
[4] Manufactured by Sierra Chemical Company, Milpitas, California



Micronutrient levels for growing on rooted cuttings the second year.

Figure 1. Treatment combinations used to determine parent plant micronutrient level effect on growth of rooted cuttings from those parents An identical treatment combination was used with Esmigran at 0, 4, 6, and 8 lbs/ cu yd

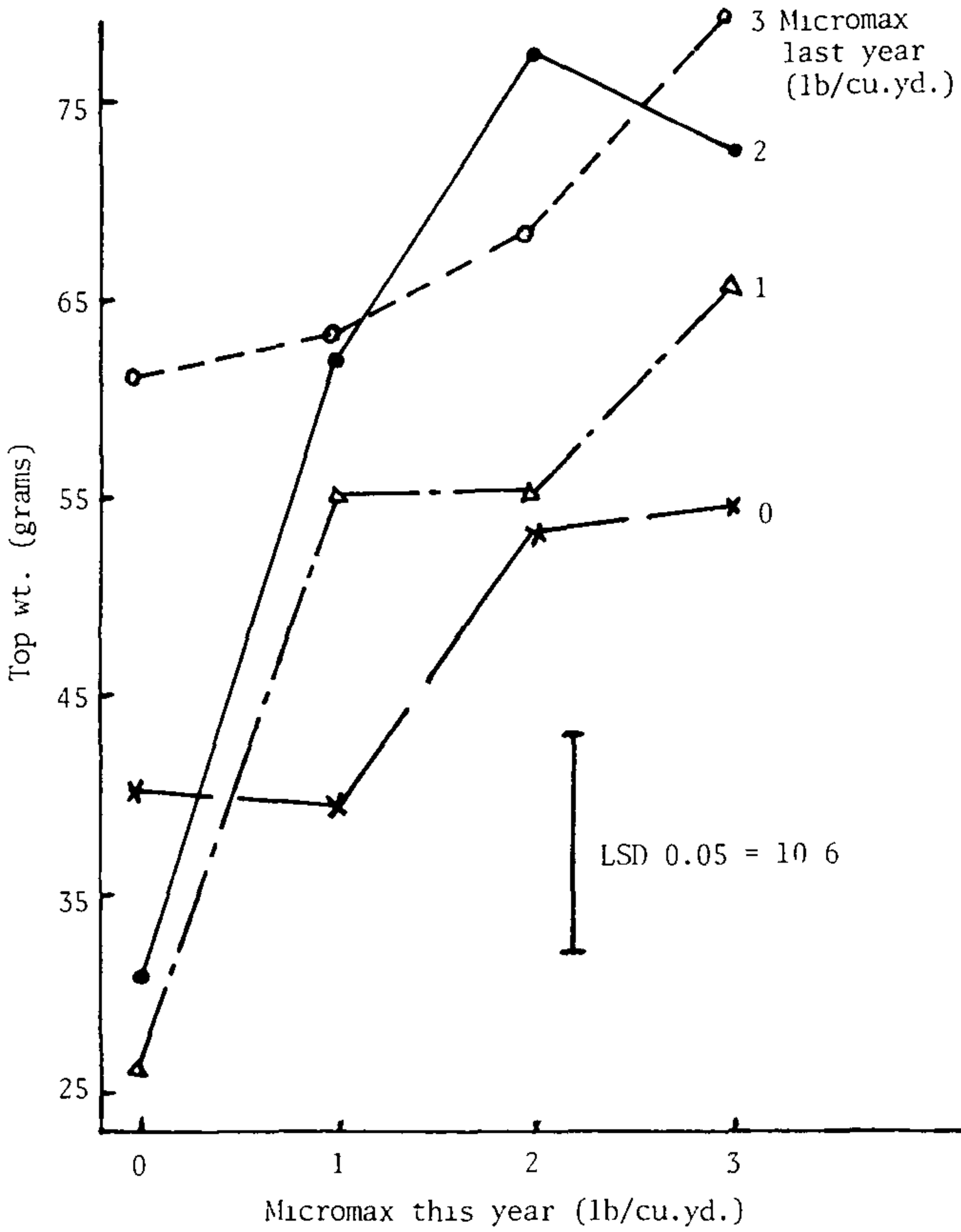


Figure 2. Effects of Micromax micronutrients on growth of Hetzii Japanese holly plants from cuttings in which parent plants received 0, 1, 2, or 3 lbs last year and 0, 1, 2, or 3 lbs this year in all combinations.

October 28, 1978. All cuttings were evaluated after 8 weeks for rooting and held in the propagation greenhouse until they were planted on April 10, 1979.

Rooted cuttings from each parent plant-micronutrient fertilizer treatment were planted into 1 gallon containers having different micronutrient levels (Figure 1). All other factors were held constant: 14 lbs 18-5-11 Osmocote, 8 lbs dolomite, 3 lbs gypsum, and 1½ lbs 0-46-0 per cu yd in a growing medium of 2 parts ground pine bark, 1 part peat, and 1 part sand. All plants were grown under 30% shade.

RESULTS

Experiment 1. Micronutrients incorporated into the growing medium of the parent plants not only stimulated plant growth but also improved rooting of cuttings taken from those plants. All rates of Esmigran and Micromax increased the root grade and the percent of liners graded 4 (minimum acceptable roots) or better (Table 1). Esmigran at 6 and 8 lbs and all Micromax rates also increased the number of liners showing new growth prior to the spring planting (Table 1).

At the end of the 1979 growing season, benefits from Micromax micronutrients applied to the parent plants in 1978 were apparent (Figure 2). Rooted cuttings from parent plants grown with Esmigran produced erratic growth the second year and data is not presented. Hetzii Japanese holly parents grown with no micronutrients and rooted cuttings from those parents receiving no micronutrients the second season were very stunted and chlorotic (Figure 3). By contrast, plants from parents receiving 4 lbs Esmigran/cu yd and grown the second season with the same treatment as the parent plants were somewhat better. However, plants from parents grown with 1 or 2 lbs Micromax and grown the second season with the same treatment were of excellent quality (Figure 3).

Table 1. Rooting response of cuttings taken from parent plant *Ilex crenata* 'Hetzii' grown with varying micronutrient levels

	Control	Esmigran lbs/cu yd			Micromax lbs/cu yd		
Average	0	4	6	8	1	2	3
root grade[z]	4 2[y]$_a$	5 2$_b$	5 8$_b$	5 4$_b$	5 5$_b$	5 8$_b$	6 7$_c$
Percent graded #4 on higher	64 0	83 9	81 4	95 2	81 5	85 1	96 4
Percent of liners showing new growth	58 1	57 6	71 4	66 5	66 4	66 5	81 5

[z] Based on a grade scale of 1 = no roots to 10 = excellent rooting

[y] Values are averages of 80 observations (10 reps × 8 subsamples) Values followed by the same letter are not significantly different at 5% level

Figure 3. Plants from cuttings from treated parents. No micronutrients for parent or 2nd year (left); Esmigran @ 4 lbs parent and 2nd year (2nd from left); 1 lb. Micromax parent and 2nd year (2nd from right); and 2 lbs. Micromax, parent and 2nd year (right). Photo taken August, 1979.

METHODS

Experiment II. Japanese holly cuttings were taken from a standard block of plants on October 29, 1978 and rooted in a peat-perlite rooting medium. The cuttings were held during the winter in a heated propagation house following rooting and were planted into 1 gallon containers with treatments of 0, ¾, 1½, or 3 lbs Micromax or 0, 4, or 6 lbs Esmigran/cu yd on April 16, 1979. The growing medium and other nutrient levels were the same as in Experiment I.

RESULTS

At the end of the growing season, the plants receiving no micronutrients were nearly as good as the plants receiving 1.5 lbs of Micromax in the growing medium (Figure 4). Plants grown with 4 lbs Esmigran were far superior to plants in Experiment 1 study (Figure 3). All micronutrient sources and rates had produced Hetzi Japanese holly plants of similar quality. This was in direct conflict with data from the parent — second year carryover study (Experiment I) and previous studies comparing sources and rates of micronutrients.

After investigating several factors, i.e. calculations, rates, and mixing procedures, the reason for the difference in plant response was found. Plants in Figure 3, the parent—2nd year carryover study (Experiment 1) had been rooted in a propagation mix of 1-1 peat and perlite with 9 lbs 18-6-12 Osmocote but with no micronutrients added. However, plants in Figure 4 were rooted in the standard 1-1 peat and perlite mix for general use in various experiments which contained, in addition to the 9 lbs of 18-6-12 Osmocote, 1 lb Micromax micronutrients/cu yd. No visual differences could be detected between the 2 sources of liners at planting time (April, 1979). However, the effect of the 1 lb of Micromax during propagation had a pronounced effect on plant

Figure 4. Hetzii Japanese holly grown with, left to right, 0, 4 lbs Esmigran, and 1.5 lbs Micromax/cu yd. Photo taken late October, 1979.

Figure 5. Hetzii Japanese holly grown with 1.5 lbs. Micromax micronutrients per cu yd in both one-gallon containers, with no micro's during propagation (left) and with 1 lb Micromax during propagation (right). Both plants were grown under identical conditions and are the same age. The liner in the center is typical of the size of liner and propagation container used in both studies. Photo taken late October, 1979.

quality at the end of the growing season (Figure 5).

Because the plants were from separate experiments some doubt remained, even though our records confirmed the difference in propagation mixes, concerning the cause of the substantial difference in plant growth and quality. A study was set up for the 1980 season to measure the effects of 0, ¾, 1.5, and 2.25 lbs of Micromax micronutrients during propagation in combination with 0, ¾, 1.5, and 2.5 lbs Micromax in the one gallon containers. Results confirmed our suspicions regarding the beneficial effects of micronutrients during propagation.

Micronutrients in the propagation medium provided substantial benefit to plant growth and quality at an extremely low cost. However, plants must be kept clearly labeled during the entire growing season to observe the differences since no visually detectable difference exists between rooted cuttings with or without micronutrients at planting time.

PROPAGATION WITHOUT MIST

BRYSON L JAMES[1]
P.O. Box 13
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INTRODUCTION

Motherhood, apple pie, and mist propagation — guess which isn't sacred? Since misting revolutionized the propagation of softwood and semi-hardwood cuttings, innovators have devised many types of control systems trying to perfect misting cycles to fit virtually every situation. Seldom do we see any two propagators using exactly the same system, nor should they, because water sources, media differences, geographic location, plant species and many, many other variables dictate unique systems.

After many years of trying to help growers perfect their misting systems, we finally decided that mist wasn't sacred. As a result we stumbled onto a system without mist that you may want to try. It eliminates the major problem propagators encounter when using many misting systems; i.e., too much water. Also, concerns about power failure, clogged nozzles, iron and/or other solids deposits on leaves, nutrient leaching, and variable weather are eliminated.

Preventing moisture loss from the plant material is the primary objective of any system used when propagation is by cuttings. Misting prevents moisture loss by maintaining a film of water on leaf and stem surfaces. High humidity systems as described by Milbocker (1) use foggers to create 100% relative humidity and thus prevent or minimize transpiration losses. In this paper we are describing a very simple system of providing 100% relative humidity without the use of foggers or misting systems. Time and method of taking cuttings, rooting media, hormones, and fertilization are not discussed here because it is not necessary to change any of these to use the system described below

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[1] Consulting Horticulturist

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Place the rooting medium in beds or in pots and water several days before sticking cuttings to insure that the medium is thoroughly wet. As soon as cuttings are stuck, water thoroughly again. Drench and/or spray with a good fungicide then cover with white (not clear) plastic film supported by wire mesh. Completely seal all edges of the plastic by burying or securing with lath strips.

In addition to the white plastic film, a minimum of 50% shade should be provided with lath, with shade cloth or by a naturally wooded area. This is to further reduce direct sunlight, which could cause excessive heat buildup. Best results are obtained if the shading material does not contact the plastic film. A few feet of air space between film and shading material is desirable.

Check the structure daily for droplets of condensation on the inner surface of the plastic film. If condensation remains on the film during the hottest part of the day, 100% relative humidity is assured. The plastic seal should not be broken until cuttings start to root, usually 4 to 6 weeks. At this time, lift the plastic covering in order to fertilize and water lightly. Replace the plastic covering but do not seal completely. Gradually provide more aeration by raising the edges of the plastic or by cutting increasingly larger slits in the film. During the hardening-off process light watering will be required. Leave the plastic over the top of the beds to protect from rainfall but leave the sides open once the cuttings are well rooted.

The greatest hazard with this system is excessive heat build-up, so choosing the best white plastic film and shading material is important. Monsanto 602 white plastic film has been the best in our experiences. Table 1 shows why. We suggest that shading to achieve light intensities of 4% or less of full sunlight is desirable for mid-summer propagation in the south.

Table 1. Comparative light intensities measured under various films and shade materials with sunlight at 1100 foot candles [1]

	Ft Candles	Percent Full Sunlight
Sunlight	1100	100
Monsanto 602 White	90	8
Dayton Co-polymer	220	20
Poly-dress Yellow	520	47
Monsanto 602 White plus 47% shade	42	4
Dayton Co-polymer plus 47% shade	130	12
Poly-dress Yellow plus 47% shade	220	20
Monsanto 602 White plus 72% shade	28	2 5

[1] Data courtesy T J Lipton Research Farm, Wadamalaw Island, S C

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1 Milbocker, Daniel C 1979 Propagation with Agritech humidifier *Proc SNA Research Conference* 24 215-16

PROPAGATION WITH AN AUTOMATIC TRAVELING BOOM

JAMES GILBERT

Gilbert's Nursery, Inc.
Route 1
Chesnee, South Carolina 29323

I would like to describe a traveling boom propagation system used for misting, watering, pesticide spraying, fertilization, and photoperiod control.

Gilbert's Nursery is located in northwestern South Carolina in USDA Hardiness Zone 7. We propagate and grow about 275,000 1-, 2-, 3-, and 5-gallon plants annually. Forty-five percent are conifers and 55% are broadleaved evergreens. All cuttings are stuck directly in Lerio SR325 plastic pots in flats in a medium of 70% pine bark (½" or less) and 30% coarse perlite. All cultivars are treated with Hormodin #2 or #3 and placed in greenhouses under intermittent mist. After rooting the liners remain in place until canning in April.

Our first two mist houses were equipped with stationary ¾ inch pipes with Flora-mist nozzles placed every 3 ft. This system has worked well in the past, but there were a few problems. These houses were not level, so when the pipes were leveled to prevent excessive dripping, they were closer to the ground on one end of the house. These pipes were supported by wires attached to the bows. Workers often bumped into the pipes and wires. While the old system had 160 nozzles per house to keep clean, the new one has just 16. The old system worked well for several years, but we wanted something better and more versatile.

In 1979 we purchased our first automatic traveling mist system from the Jaderloon Company, Box 685, Irmo, South Carolina 29063. We believe it has solved many of the problems associated with the old system, and offers many opportunities for improved liner production.

The boom travels from one end of the house to the other and returns (Figure 1). Spraying Systems Company nozzle body assemblies are located at about 1-ft intervals along the boom. Interchangeable nozzles and check valve strainers can be removed for cleaning. Many nozzle tip types and capacities are available, but we have had the best results from a hollow cone 5x tip and a

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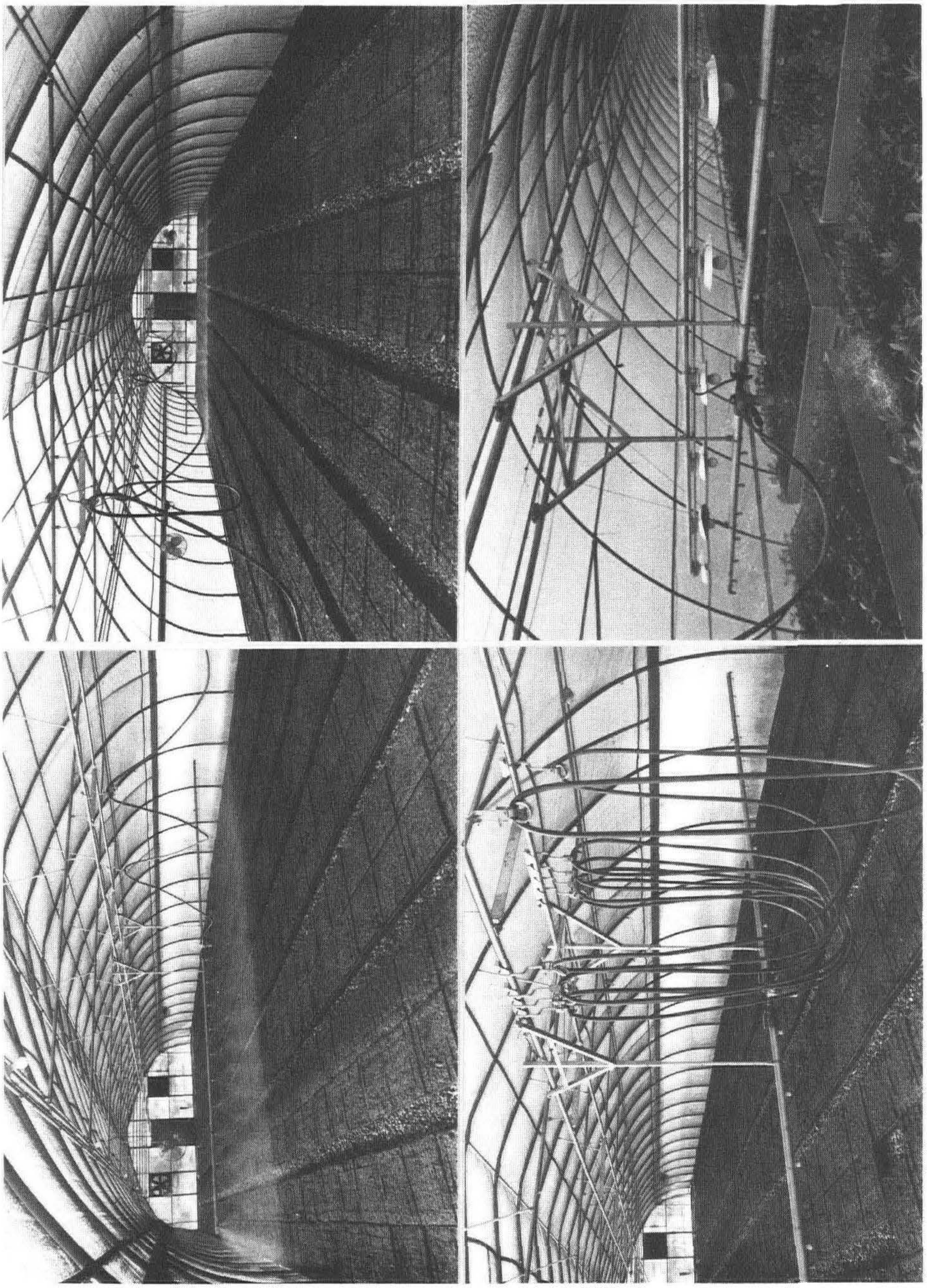

Figure 1. *Above left:* Mist boom in action. *Above right:* Mist boom approaching far end of house. *Lower left:* Boom returning to start position. *Lower right:* Boom with attached lights for photoperiod control.

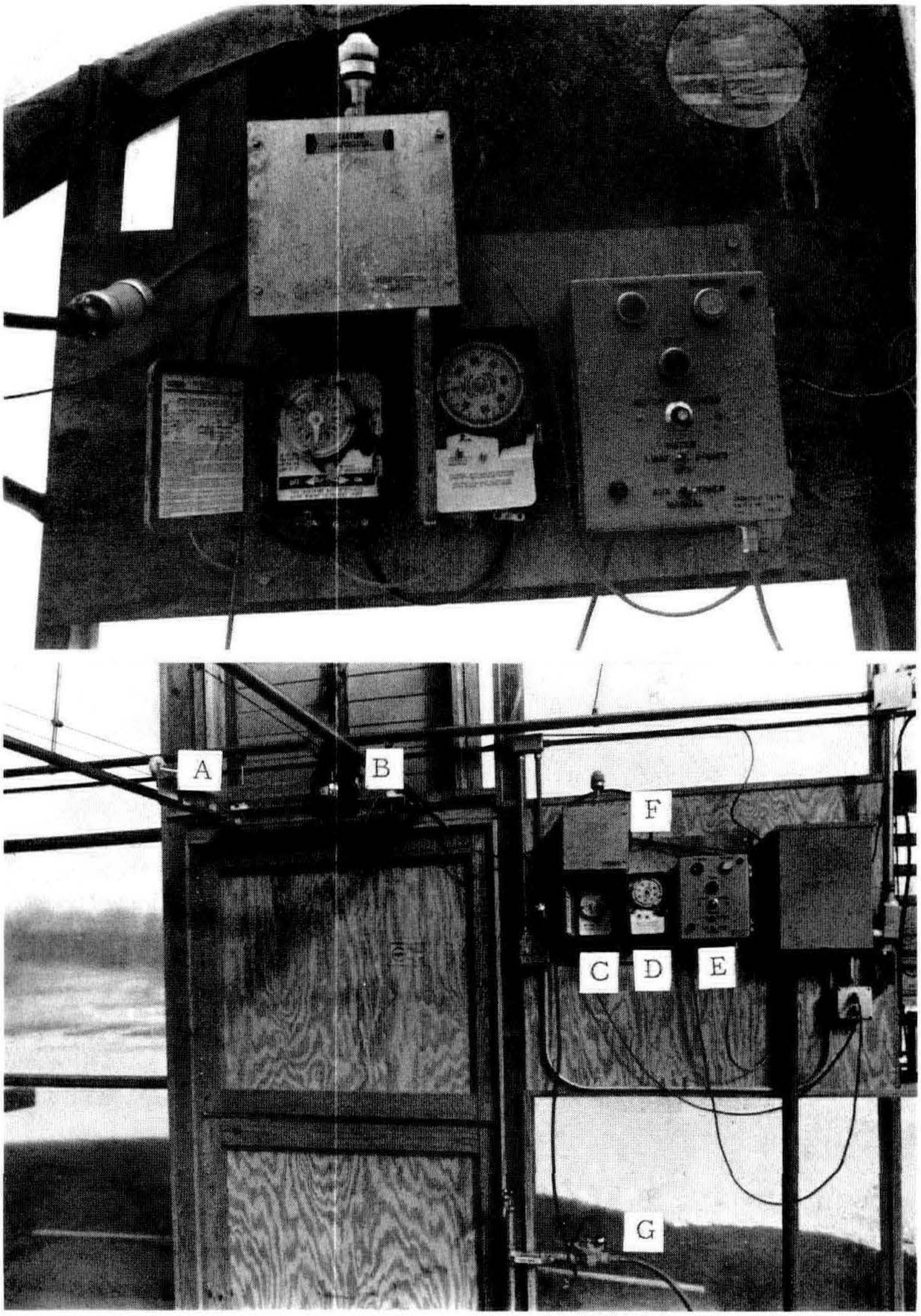

Figure 2. *Above:* Close-up of time clocks, main control panel, and lighting controller

Below: View of the main controller and drive mechanism from left to right:

A Switching mechanism and switching cable
B Reversible gear motor and drive cable loop
C Day-nite timer
D 2 hour interval timer
E Main control panel
F Optional lighting controller for photoperiod control
G 24-volt solenoid valve and hose attachment

TeeJet 8001-E tip. The boom is attached to an aluminum frame which travels on rollers along a set of parallel rails attached to cross braces in the greenhouse. One end of a ⅝ inch water hose is connected to the boom strainer assembly and looped through hose trolleys which roll along the rails. The other end is fastened to a 24-volt solenoid valve. A small gear motor turns a cable loop running the length of the house to move the frame along the rails. Another cable with adjustable cable stops trips the switching mechanism that is wired to the main control panel.

A typical installation requires a 24-hour clock for turning the system on and off each day, an interval timer (2 hour) to set desired starts in the mist cycle, and the main control panel. This control panel can be set to operate by the timer, or by manual, or auxiliary modes (Figure 2). Water can be applied as the boom travels down the house only, or both down and back. The boom travel speed can be regulated from 0 to 30 ft per minute by a dial on the panel. Forward, reverse, and stop buttons are included. On setting #8 the boom travels about 30 ft per minute, on #6 about 20 ft per minute, and on #4 about 10 ft per minute. We prefer the #4 setting.

Misting. When cuttings are being stuck the system is set to water one way every 10 minutes with boom speed set at #8. The system is set to be on from 9 a.m. until 5 p.m. during the summer and from 10 a.m. until 4 p.m. during the winter. As cuttings begin to root the starting times are adjusted from 10 minutes to 15 minutes, 20 minutes, 30 minutes, etc., until no mist is being applied. With the many possibilities available concerning time of day on, starting intervals, boom speed, and nozzle size, the propagator can choose an infinite combination of possibilities to suit his crop and conditions.

Watering. After the crop is well rooted and watering is needed, we turn the auxiliary switch on to make the boom operate continuously, flip the switch to water both ways, and slow the boom speed to #4. We leave the system on until the desired wetness is achieved.

Spraying. Foliar feeding and pesticide spraying is easily done with the boom system. We use a gasoline-powered pump with a truck-mounted 200 gallon tank for spraying. The correct amount of fertilizer or chemical is placed in the correct amount of water in the tank. The pressure regulator is set at about 60 psi. A bypass agitator keeps the chemicals, especially wettable powders, mixed properly. The hose is removed from the solenoid valve inside the greenhouse and is connected to the outlet on the sprayer, which is located outside the greenhouse. After turning the sprayer outlet on for a short time to flush out the clear water in the hose and boom, the water switch on the main control

panel is turned off and the forward button is pressed. Setting #8 is generally adequate for a good spraying during one complete forward and reverse cycle. The amount of cycles needed depends on the boom speed, nozzle size, pressure, and the total amount of chemical needed per house to achieve proper results.

Drenching. Drenching is basically the same as spraying, with the following exceptions. The auxiliary switch is turned on to make the boom move continuously until the desired amount of material has been applied and the boom speed is slowed to #4.

When the spraying or drenching in one house is complete, I move on to the next house and repeat the procedure. While the next house is being sprayed, the hose in the previous house is reconnected, and switches returned to the desired settings. I flush the hose and boom with clear water and clean the main strainer and individual nozzle strainers. There have not been any problems with clogged nozzles when wettable powders are used. One big safety advantage to this method of spraying is that the operator doesn't have to be in the greenhouse when spraying is taking place.

Photoperiod. In an experiment and paper I did while a student at North Carolina State University, I found that the tops and roots of two *Ilex crenata* cultivars grew almost twice as fast when 4 hours of light were added from 10 p.m. to 2 a.m., compared to plants receiving only 8 hours of natural light. I do not think that lights will be useful for all cultivars we grow, but I plan to test this further. I plan to root as many cultivars as possible during the summer months, keep the liners just above freezing during the coldest months, and raise the night temperature to 65-70°F and begin cyclic lighting in late February to get a good flush of growth before canning in April. Any results I obtain may be reported later when more data is available.

Light fixtures spaced 20 inches apart with 100 watt incandescent bulbs were mounted to a pipe clamped to the boom frame about 30″ above the lines (Figure 1). A 125′ 14-3 drop cord was then taped to the water hose and back to the area of the controller. A light-sensor-controlled relay turns the system from a watering mode to a lighting mode after dark. An extra set of on-off trippers was added to the 24-hour clock to turn the light on at 10 p.m. and off at 2 a.m. When the lights come on at 10 p.m., or any previously set starting time, the boom travels continuously back and forth, applying cyclic lighting to the crop until the lights are cut off at 2 a.m. We are lighting 10% of the growing area at any one time with from 10 to 60 footcandles. Directly to either side of center under the boom measures about 60 foot candles, reducing to about 10 foot candles 5 feet ahead and 5 feet behind the boom.

Compared to conventional mist systems, the mist boom by

Jaderlon has a greatly reduced amount of plumbing and obstructions, and the mist boom with lights offers similar advantages over stationary wiring arrangements and requires a reduced electrical capacity. The approximate current cost of the time clocks, controller, boom frame, watering boom, solenoid valve, hose, and rails is about $1750 for a 28 ft × 100 ft greenhouse. If cross braces are needed, add $180. The lighting sensor, relay control panel, electrical cord, and light boom cost about $300. The cost of a typical unit for mist, spraying, and lighting would probably be about $2250 at 1980 prices. This may seem expensive for a mist system, but considering the additional uses, I feel the cost is justified I am enthusiastic about the Jaderloon traveling boom for misting, spraying, and photoperiod control for propagation and greenhouse production.

VENTILATED HIGH HUMIDITY PROPAGATION

D.C. MILBOCKER

Virginia Truck and Ornamentals Research Station
Virginia Beach, Virginia

Two types of propagation are commonly used by nurserymen: (1) high humidity propagation where cuttings are prevented from wilting by preserving a humid environment, and (2) mist propagation where cuttings are prevented from wilting by restoring the water lost by evaporation from the cuttings. High humidity propagation remains in use because some species of plants propagate quite easily with this method, a few of which are more difficult to propagate by other means. Its greatest weakness is low humidity stress following sudden temperature increases. The effect of this weakness is minimized by taking small cuttings during the cool season and placing them in small enclosures located in shade. Intermittent mist propagation is the product of progress from manual sprinkling to automatic misting. It is popular because cuttings can be successfully propagated and the results repeated due to automatic programming. Its weakness is the difficulty of adjusting the water distribution rate, which must be increased during hot dry weather and decreased during cloudy, wet and cool weather. Consequently, cuttings may be exposed to either or both inadequate and excess moisture. Too much moisture saturates and cools the propagation medium. Excessive cooling and saturation have been overcome to some extent by using coarse, easily-drained media, and supplemental heat.

Most efforts to combine misting with high humidity for propagation have resulted in increased temperatures and greater saturation of the propagation medium because of decreased evapora-

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tion. Thus, the weaknesses of each system were combined. Nevertheless, some restrictions to evaporation, if no more than wind protection, are used on most misting systems. Fully enclosed and unventilated mist systems maintaining 100 percent humidity are seldom found. The objective of this research was to develop a method of combining the best qualities of mist (automatic programming) and high humidity (no saturation). Unlike typical high humidity systems, high temperatures were controlled with ventilation, and unlike mist systems, water droplets humidified the air and were not intended for wetting leaf surfaces. Thus, by controlling both temperature and saturation, a better environment for cuttings was accomplished.

Saturation of the propagation medium was minimized by reducing droplet sizes. Droplets greater than 50 microns in diameter descend rapidly, wetting the foliage of cuttings and the surface of the propagation medium. Droplets smaller than 10 microns are termed aerosols and remain in suspension, even in calm air. These droplets require large amounts of energy for their generation and are therefore questionably feasible for economic reasons. Intermediate-sized droplets, between 10 and 50 microns, were small enough to be carried on air currents yet large enough to be economically produced. Based on the formula for droplet volumes, droplets of this size generated from equal quantities of water outnumber heavier droplets by more than 8 to 1. These

Figure 1. Humidifier to supply high humidity for propagation.

smaller and lighter droplets expose much greater total water surface to the air. By locating a fan behind the humidifier generating the droplets, a flow of droplet-laden air was produced. Evaporation further reduced droplet sizes to those of aerosols as

they traveled from the fan, and evaporated moisture humidified the air satisfactorily for preventing wilt stress of cuttings.

Solar heating takes place at points of light absorption, which, in this case, are the cuttings and propagation medium In a high humidity environment very little evaporation or evaporative coling occurs from the cuttings and propagation medium. The resultant rise in temperature of a few degrees served as a type of natural bottom heating. Excess heat was transferred to the air flow and carried through the exhaust vent The area of coverage was increased by suspending the fan and humidifier by an oscillator, which moved the air flow through an approximate 90 degree horizontal arc. (Figure 1).

Both temperature and saturation of the propagation medium were controlled with this system. The temperature was determined by the intensity of sunlight and rate of ventilation. The light was reduced approximately 50% by shading during midsummer. Convective venting further reduced the temperature since air moved more rapidly through the exhaust vents as the temperature rose. Therefore, one size of opening functioned effectively throughout daily temperature fluctuations. Reducing or increasing the size of the inlet vent provided manual control of the temperature. The cross sectional area of this vent measured approximately 1% of the floor area during hot weather and was reduced until closed during winter weather.

The humidifier was suspended between the inlet vent and the cuttings to assure humidification of dryer ambient air Saturation of the propagation medium was controlled by the rate of humidification, which was easily changed at the flow meter on the humidifier. Low rates caused some wilting of cuttings most distant from the humidifier High rates saturated the medium near the humidifier from the descent of heavier droplets formed from collisions of smaller droplets. Useful rates were quite flexible and ranged between 1 and 2 gal per hour per 100 sq ft of floor area covered. All cuttings had to be confined to the airflow pattern of the fan and its oscillator The arc of the pattern was approximately 90° and extended 30 to 40 ft Within this pattern suspended moisture evaporated and prevented wilting on sunny days. On cool cloudy days, most of the moisture remained in suspension and was carried out through the exhaust vents. By using this system, it is possible to adjust the water flow rate and the air intake rate to produce highly favorable conditions for propagation.

COLD STORAGE PRETREATMENT OF CUTTINGS

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This paper concerns the storage of Japanese holly cuttings *Ilex crenata*, at near freezing temperatures for 10 and 12 weeks before propagating. Dormant tip cuttings were made prior to spring growth and rooted after propagation houses were emptied by spring plantings. This work was done by D.C. Milbocker and T.J. Banko using the research facilities of the Virginia Truck and Ornamental Research Station, Virginia Beach, Virginia.

Although we did not dislike what we were doing, we felt we could do better. Our present method gives us nicely-rooted liners in August, and we usually get a fall flush of growth. The following April the liners are potted 3 to a 3-gallon bucket and moved to the field. We cannot economically compete in the 1-gallon market with growers in the 3-gallon market, and we want our product to be the best available. Since we then get 3 flushes of growth — one in June, one in July, and one in August — we are pleased with our field operation. The plants are 12 to 15 in high and well-branched at the end of the growing season.

We do not see any way of getting an additional flush in the field. However, since we sell by plant size, we could get more return on our investment in the plant by adding one more growth cycle to our system. This gave us an idea that we call our 60 MPH theory. With our present method, growth starts in May, and by the end of the summer the plant is going 60 MPH. It is still ready to go when cold weather comes. If we could take our cuttings in January, we might be able to add an additional flush before moving the plants to the field. The unrooted cutting would be at 0 MPH. When it rooted it would be at 10 MPH and at 20 when the first flush occurred. We could have that plant already going 35 MPH by the time we went to the field in April. If we could go to the field with a 6- to 18-in liner rather than a 3- 4-in we believe we could have a 15- to 18-in 3-gallon plant by that fall. By taking cuttings in January we could also distribute our work load and make better use of our employees' time during the winter.

Our last killing frost is traditionally considered to occur in April. After that time we have greenhouse space available using our present system. We decided to use this space to test our theory, with the help of Dr. Milbocker and Dr. Banto.

During the last week of February, 1980, 12,000 tip cuttings were taken of each of the following 4 cultivars of Japanese holly: *Ilex crenata* 'Helleri,' 'Nigra Upright,' 'Bennett's Compactum'

and 'Wight's Compactum.' The cuttings were 7 in long with basal leaves stripped in the field. The cuttings were placed into bundles of 25 held by a rubber band. Each bundle was dipped in a Daconil (chlorothalonil, Diamond-Shamrock) solution. After draining, half of the bundles were dipped in a 2500 ppm IBA-alcohol solution.

The cuttings were then taken to the Research Station where they were divided into four additional treatments: storage under 8 hours of light per day, or no light, in plastic bags, or in open flats under high humidity. Light was supplied by a single 40-watt fluorescent tube positioned over the cuttings. High humidity conditions were maintained by sealing the cuttings from circulating air and generating humidity from fog nozzles. The temperature was maintained between 1 and 2°C.

Half of the cuttings from each treatment were removed the first and third week in May. Cuttings that had not received a hormone treatment were dipped in 2500 ppm IBA just prior to sticking. They were stuck into 3-in pots, with pine bark as the rooting medium, under intermittent mist.

I am sure that Dr. Milbocker and Dr. Banko have the statistical data to show which treatment was best from the research point of view, but the best visual treatment was no lights, sealed in bags, quick-dip in 2500 ppm IBA hormone added at time of sticking. Most all of the cuttings rooted in a satisfactory percentage.

Our hope was that the cuttings would root prior to top growth. They did this, but we then ran into trouble. The first strong flush of growth came around the first week in June, and we were not ready. We used liquid fertilizer injected into the water lines in the propagation area. The other cuttings that were being made were not ready for fertilizer, so the house with the experiment was starved during a time when we should have been feeding heavily. This resulted in plants becoming off-color and stunted. the advantage we had gained from early rooting was lost.

We believe that we can gain an advantage by taking cuttings earlier than usual. Our results show that we cannot do so by changing only one step in the production cycle. It is critical that all other phases of the entire process be considered as well. We plan to repeat this work next season with modifications. We are going to stick the cuttings directly into an unheated poly house with some form of slow-release fertilizer in the rooting mix.

SOIL-BORNE FUNGUS DISEASES OF ORNAMENTALS

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Soil-borne fungus pathogens exist in soil, water, or in or on infected roots. Fungi may also reside in crown and foliar tissue as both mycelium, spores or resting structures such as sclerotia or chlamydospores. Spores or resting structures may be transmitted by tools, equipment, pots, benches, flats, shoes or any other items that may harbor bits of infested soil.

Fungus propagules may be disseminated in water used for irrigation, in soil used in containers, and with soil particles splashed, blown, or otherwise moved to susceptible plants. Soil insects may also transmit pathogenic soil-borne fungi. Soil-borne fungi comonly invade plants at or below the soil line and disease development begins before top symptoms are detected. During prolonged periods of high humidity accompanied by splashing water, fungi such as *Phytopthora, Rhizoctonia, Cylindrocladium, Sclerotium* and *Pythium* infect and colonize stems, petioles and occasionally leaf tissue. The youngest tissues are the most susceptible with resistance increasing as the host tissue matures.

PATHOGENIC FUNGI THAT CAUSE ROOT ROT

Rhizoctonia. This fungus has been reported to cause more different types of diseases, to a wider variety of plants, over a larger part of the world, and under more diverse environmental conditions, than any other plant pathogen. Rhizoctonia survives as thick-walled mycelium and sclerotia in the soil and in plant debris. All plant parts are attacked with the greatest amount of damage to roots. Not only are most field soils infested, but we have observed that pine bark will support survival of the fungus and infection of cuttings. Rhizoctonia may cause a severe aerial (foliar) web or thread blight during propagation with colonization of leaves and stems of plants crowded in containers.

Growers identify *Rhizoctonia* infection by the reddish-brown mycelium resembling fine threads or webs that appear on diseased tissue. In addition the mycelium or threads can be noted on the soil surface growing among soil particles. Mycelial threads fasten infected leaves of cutting to the particles of the propagation medium, making it difficult to lift the infected leaves. Leaves in close proximity to one another on crowded plants will have mycelium evident as webs that tie the infected leaves together and prevent them from falling off the plant.

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[1] Associate Professor and Professor, respectively.

Phytophthora. Several different species of *Phytophthora* infect ornamentals. They all belong to the group commonly referred to as water molds and attack roots, stems, foliage, fruits, tubers, rhizomes and seed. Survival in the soil in the absence of a suitable host occurs as oospores, chlamydosores and mycelium in the tissues of host plants. Symptoms of infection are apparent as water-soaked mushy roots which turn dark brown to black when they dry, leading to complete destruction of affected tissue. On stems sunken cankers cause girdling, leading to top wilt and eventual death. Some species are restricted to roots whereas others cause leaf spots, leaf blights, collar rot and stem rot.

Disease development is rapid if the growing medium is poorly drained or kept wet for extended periods. Frequent wetting of the leaves and stems provides favorable conditions for leaf and stem infection. Wide spacing of plants, culture on benches above ground, well-drained growing media, and proper management of water will prevent serious disease.

Pythium. Mature tissues of plants are not generally infected by *Pythium*. Seeds, seedlings, young roots and stems are susceptible. Warm-wet or cool-wet soils favor disease. Several species of this fungus are reported to cause root rot and the different species have different optimum conditions for growth. Resting structures like oospores allow these fungi to survive during adverse environmental conditions. Once established in a crop area *Pythium* is difficult to eliminate. Water stored in irrigation ponds, running water, soil and peat-moss are all sources of *Pythium*. Hot water dips have been used successfully to eliminate the fungus and may be used if infected plant parts must be used for propagation. There are several species of *Pythium* that have been recovered from the roots of diseased ornamentals, including *P. splendens*, *P. irregulare* and *P. aphanidermatum*.

Sclerotium rolfsii. Diseases caused by this fungus are commonly referred to as "Southern Blight" or "Southern Stem Rot." Usually the fungus invades the stem region near the soil line and is particularly severe in propagation. There are many hosts with at least 500 species susceptible.

The fungus survives between periods of pathogenicity as sclerotia in plant debris and soil and can remain viable up to 5 years. High soil moisture, acid pH (3.0-5.0), optimum temperature of 25°-35°C (77° to 95°F) and adequate aeration favor a high incidence of this fungus. Movement of the fungus occurs by wind, water, infected propagative stock, or by transplants and infested plant debris. The symptoms of disease are wilting of the plant, preceded by water-soaked, usually brown, stem lesions at or near the soil line. Coarse white mycelium appears on the lesions and radiate over the soil surface and is interspersed with

small, round, light tan to dark brown sclerotia which resemble mustard seeds. Diseased plants become girdled, frequently collapse and die. Various kinds of propagative material are infected including cuttings, tubers, corms, rhizomes and bulbs. Plant material that becomes infected should be removed and destroyed so that the sclerotia are not spread. If the medium used for propagation has become infested with the fungus, it should be discarded. Soil from fields in which susceptible crops have been grown should be avoided. These include peanut, soybeans, tobacco and tomatoes.

Fusarium. There are many species and forms of *Fusarium.* They have been implicated in the decay of bulbs, corms, tubers and seed. Dry root rots and vascular wilts are symptoms of certain species. Others cause damping-off and stem cankers. Diseases caused by *Fusarium* are more prevalent during warm to hot periods and are not measurably affected by changes in soil moisture Spread of the fungus occurs on propagative material, seedling transplants, wind-borne soil, surface drainage water, and contaminated implements and equipment.

Sclerotinia. Cottony rot is a commonly used term for the disease caused by this fungus. A prominent mass of white, lace-like mycelium produced on the host plant is a characteristic feature of this fungus. Roots, stems, leaves, petioles, flowers, fruits and storage organs are susceptible. Large, black and easily seen sclerotia of this fungus persist in the soil, usually within the top four inches of soil. The sclerotia germinate to produce mycelium or fruiting structures (apothecia) which produces spores that are wind-borne or splashed onto new hosts.

Thielaviopsis basicola. This fungus is a soil-inhabiting fungus attacking the roots and hypocotyls of many ornamentals. The disease has been found to be affected by environmental factors such as pH, temperature, soil moisture levels, organic matter, and aeration. Survival of the fungus in soil appears to be influenced by aeration, organic residue, by pH, and by antagonistic organisms.

This fungus formerly was well known for its importance in poinsettia production. However, largely through sanitation, now the fungus is rarely found associated with poinsettia roots. Recently we have found Japanese holly *(Ilex crenata)* to be a host with severe damage occurring in some cultivars. Other species of *Ilex* like Chinese and English holly have a high degree of tolerance to this fungus found on Japanese holly.

Thielaviopsis has two main spore forms, hyaline thin-walled endoconidia and large, thick-walled chlamydospores. Both types are produced in abundance or in or on infected tissue. Chlamydospores appear to be the main propagule responsible for the

long period of survival in the soil.

Cylindrocladium. Several species of this fungus have been reported causing leaf spot, wilt and root rot on azalea, vomitoria holly and magnolia. The principal species involved in woody ornamentals disease are *C scoparium* and *C. floridanum* Disease incidence and severity are closely related to high humidity.

When cuttings are infected, there is poor root development. Leaf spots on azaleas are circular to irregular in shape and reddish brown, occurring at the tip or margin of the leaf. The wilt phase is closely related to stem canker development. Brown to black cankers form near the soil line and soon the vascular tissue becomes infected This is followed by a rapid wilting of the leaves starting with the top branches of the plant. Brown mycelial growth may be seen on both leaves and stem cankers, particularly during high humidity.

Cuttings should only be collected from healthy stock plants. Fungicides may be applied to the stock and to the cuttings.

MANAGEMENT OF ROOT ROT DISEASES

Pathogens are introduced into the plant production system in a variety of ways. It has been stated frequently that soil is the most common vehicle but water and such components of soilless or artificial media as peat moss and pine bark are also possible sources of pathogens. Growers who use soil in containers should pasteurize it before using, preferably with aerated steam, or fumigate with a volatile chemical to eradicate the resistant structures such as sclerotia and chlamydospores. The implements used in the greenhouse or in the field should be frequently sterilized to eradicate fungi and bacteria. Propagation and growing benches should be raised above the ground and disinfested between crops. Growing media that is pasteurized with steam (180°F for 30 minutes) to eliminate pathogens also has its competitive microflora eliminated and is readily recolonized by fungi like *Pythium* through unsanitary practices. Pasteurization with aerated steam at 140° to 160°F does not eradicate competitive beneficial organisms and the medium is therefore not readily recolonized by pathogens.

It is common practice to fumigate fields with volatile chemicals like mixtures of methyl bromide and chloropicrin to eradicate all of the fungi, nematodes, and weed seeds, before planting high value crops. Because many of the beneficial competitive organisms are eliminated through fumigation, reintroduction and recolonization by pathogens can occur readily. Machinery from infested fields can carry pathogen-infested soil into a fumigated field and result in severe disease in the next crop.

Plant production in containers placed on plastic is a popular

method of culture. One advantage is breaking the direct contact of the container with the soil. However, depressions in the plastic can become puddles causing containers to be temporarily water logged and they also provide for movement of water molds to adjacent containers. Crowned growing beds partially eliminate the problem. A better solution is the construction of raised gravel or stone beds three to four inches in thickness to prevent the accumulation of water around the container.

Artificial or soilless media in containers must be adequately aerated with sufficient non-capillary pore space to allow rapid drainage after irrigation or heavy rainfall. Water mold-incited diseases are less severe in well-aerated media. Media that contain high volumes of small particle materials have little non-capillary pore space and retain large quantities of water leading to root rot.

Water used for irrigation can carry pathogenic fungi like *Phytophthora, Pythium* and *Rhizoctonia.* Surface bodies of water and occasionally running water can serve as a reservoir for plant pathogens. If water is recycled for irrigation, pathogens can be introduced into a previously non-contaminated medium. Wherever possible, well water should be used. City water that has been chlorinated for human consumption is recommended for propagation. If surface water supplies are suspected of carrying pathogenic fungi they should be assayed and chlorinated if found to be infested.

One of the major problems in the ornamental industry is the unavailability of stock free of pathogens, whether it be cuttings, liners or container plants. Rooted cuttings or liners may appear healthy, but when grown under conditions of high temperature and wet soil the roots will rot and they will die. Under cool conditions Japanese holly infected with the fungus *Thielaviopsis* suffer severe root rot. The infected plants make partial recovery under warmer growing conditions. In different regions of the country growers have learned how to grow ornamentals visibly free of symptoms, although still infected with root-rotting pathogens. However, when these infected plants are shipped to other states with different cultural and environmental conditions, symptoms may appear. Different environmental stress factors are required for different host-pathogen relationships.

Chemicals play a role in the protection of plants from infection. They do not eradicate established infections. Poor or even total lack of control usually occurs when the plants treated with fungicides are already infected. Failure to accurately diagnose the disease or selection of an ineffective chemical is often a source of grower frustration and wasted money. Overprotection or excessive application of chemicals is inappropriate not only

from the viewpoint of unnecessary cost, but also the unacceptable environmental pollution. Because the ornamental grower faces the prospect of controlling many different soil-borne pathogens, frequently on the same plant and often on a wide variety of plants, the choice of chemicals and the correct rate of application schedule require considerable experience and knowledge. For this reason consultants can play an important role in the development of the most efficaceous program. Soil fungicides are applied as drenches or granules. The volume of drench applied depends in part upon the size of container, depth of flats or ground beds and the constituents used in the soilless or artificial mix. Granules or wettable powders incorporated into the growing medium offer a method that may become more important in the future. The advantages of fungicide incorporation are both economical and time saving. Granules are potentially in contact with all the medium particles if they are uniformly mixed and avoid the necessity of a drench application to place the toxicant in contact with the particles. There is also the possibility that granules will have a longer period of activity. New, as yet unregistered fungicides, like Ridomil® and Aliette® offer considerable promise for the future. Fungicides recommended for protection of ornamentals against root rotting fungi are listed in Table 1.

Recent publications have identified root-rot tolerant or resistant cultivars of rhododendrons, azaleas, junipers, and hollies. In the future more emphasis should be placed on the breeding of disease-resistant cultivars instead of relying on chance for resistance.

Table 1. Fungicides for controlling soil-borne fungus root rots

Fungicide	Recommended rate	Fungi protected against
Banrot 40% W (thiophanate methyl plus ethazol)	6-12 oz/100	*Fusarium, Rhizoctonia, Phythium, Phytophthora, Thielaviopsis*
Benlate 50% W (benomyl)	8 oz/100	*Fusarium, Rhizoctonia, Sclerotinia, Cylindrocladium, Thielaviopsis*
Captan 50% W (captan)	32 oz/100	*Phythium, Phytophthora*
Truban 30% W or 5% G (ethazol)	8-12 oz/100 or 10 oz/cu yd	*Pythium, Phytophthora*
Terrazole 35% W (ethazol)	8-12 oz/100	*Phythium, Phytophthora*
Lesan 35% W (diazoben)	10 oz/100	*Pythium, Phytophthora*
Terraclor 75% W (PCNB)	12-24 oz/100	*Sclerotinia, Sclerotium, Rhizoctonia*

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HYDROPONIC FERTILIZATION OF WOODY PLANTS IN CONTAINERS

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Hydroponic fertilization is the supply of all mineral nutrients to a plant in the irrigation water. It has been used for many years, both commercially and as a research tool, primarily for greenhouse flower and vegetable crops.

The possibility of its use with container-grown woody ornamentals was first considered by us several years ago as we pondered the full range of possible fertilization methods. Incorporation into the growing medium of all nutrients needed for a year's growth was envisioned as one extreme of this range and the supply of all nutrients in the irrigation water as the other extreme. There are considerable advantages to the use of one of these extremes or the other.

One of the advantages of hydroponic fertilization is that it eliminates the necessity for mixing the medium. If an economical material is available that has the physical and chemical properties needed, plants can be potted in this material without additives. In our area the obvious choice is pine bark.

In our first test of this method in 1977 a commercial hydroponic fertilizer made by Pronto Plant Food Company was used. The 8-5-15 analysis of the material was boosted to the equivalent of 10-5-15 with urea. The "A" and "B" components were applied either simultaneously or at alternate irrigations to determine if this factor had any effect on growth. These treatments were compared with one which supplied all nutrients needed from Osmocote 18-6-12, superphosphate, dolomitic limestone, and fritted trace elements. Other treatments involved some incorporated materials and some supplied in the irrigation water.

Average growth ratings with hydroponic fertilization were higher than those with Osmocote, which were, in turn, higher than all of the "combination" treatments used. There was no apparent difference between the hydroponic treatment which supplied all nutrients at each irrigation and that which used the "A" and "B" components alternately. Therefore, in all tests since that time the alternating method has been used.

In the following year's test, a homemade hydroponic fertilizer was compared with 6 slow-release treatments and 4 combinations of incorporated and liquid fertilizers. All liquid

programs were calculated to supply an average of 150 ppm of N. The hydroponic program also supplied 50 ppm P_2O_5, 100 ppm K_2O, 122 ppm Ca, 40 ppm Mg, and all other essential elements.

'Hino-crimson' azalea, variegated pittosporum, 'Convexa' (Syn.: 'Bullata') Japanese holly, 'Dwarf Burford' Chinese holly, and 'Santa Cruz' pyracantha were used For all 5 species the quality rating for the hydroponic treatment was significantly higher than that of all other treatments.

In 1979 hydroponic fertilization was compared with 4 other treatments which made use of the best cultural practices that we had determined in a variety of previous experiments. One of these practices was the use of ⅛ soil (by volume) added to the pine bark medium for all treatments except the hydroponic one. Another was incorporation of Osmocote in the top quarter of the medium instead of throughout the medium. The 5 fertilization treatments were tried under 2 irrigation systems, sprinklers, and "spitters."

In overall quality and color ratings, hydroponic fertilizer applied through sprinklers rated significantly higher than all other treatments. The same treatment ranked significantly higher than all except Osmocote 18-5-11 with sprinklers in size rating. Hydroponic fertilization through spitters rated highest in compactness.

'Formosa' azalea, variegated pittosporum, and 'Wilsonii' English ivy performed especially well when given hydroponic fertilization, receiving high scores in all 3 criteria used: size, color, and compactness. 'Blue Pacific' juniper and 'Dwarf Burford' holly also rated very well with hydroponic fertilization, scoring very high in size and color. 'Compacta' Japanese holly was slightly lacking in size and compactness, tending to produce long, unbranched shoots. 'Richard's' harland box was slightly larger with Osmocote 18-5-11, but color was much better with hydroponic fertilization.

In 1979, we also compared various sources of P and Mg that might be used for hydroponic fertilization. Soluble sources of phosphorus are scarce and expensive. The usual source of magnesium, Epsom salts, is also rather expensive. The P sources tried were an 18-46-0, which was not completely soluble; phosphoric acid; urea phosphate; and urea ammonium polyphosphate (UAPP). The latter 2 are experimental materials from the Tennessee Valley Authority. The alternative source of Mg was sulfate of potash-magnesia.

No significant differences were found among plants grown with the various hydroponic solutions. In general, all were better than the Osmocote-fertilized check plants. UAPP would be unsuitable for hydroponic fertilization through an injector because a precipitate formed when it and $MgSO_4$ were used in

the same concentrate. The 18-46-0 and potassium magnesium sulfate had the disadvantage of leaving an insoluble residue.

A 1980 test still being evaluated is based on the fact that, while hydroponic fertilization can be economical if waste can be eliminated, the cost of applying it through sprinklers to normally-spaced plants would be very high. Therefore, plants that were planted in crowded 6 inch square pots in April were hydroponically fertilized until they were spread August 1. At this time they were given various top dressings to determine which ones carried them through the remainder of the season most effectively. These treatments are being compared with an Osmocote check and a full-season hydroponic check.

A disadvantage to purely liquid fertilization in a non-retentive medium is that if the fertilization program were discontinued in the fall and the plants were held until spring before sale, the medium would be almost completely without nitrogen and possibly other nutrients by that time. Top dressing, as in our current test, would eliminate this problem.

To give some idea of the cost involved, the hydroponic fertilizer for a 6″ diameter container, without waste, for a growing season was calculated to range from 1½ to 3¢, depending on the particular materials used. This calculation was based on 100 applications of 1 pint each. For comparison, Osmocote fertilizer at 16 lb per cubic yd would cost about 3¢ per 6 inch container.

The following formulas are offered to give a starting point for experimentation with hydroponic fertilization. The least expensive combination we know would require:

"A" solution — 168.5 g. $CaNO_3$ per 100 liters.

"B" solution — 21.7 g. 18-46-0, 90.8 g. potassium magnesium sulfate, 2.23 g. STEM and 1.11 g. Fe 330 iron chelate per 100 liters.

A more expensive, but more nearly residue-free combination would be:

"A" solution — 153.6 g. $CaNO_3$ per 100 liters.

"B" solution — 9.2 ml. of 62.5% phosphoric acid, 44.9 g. potassium nitrate, 83.3 g. magnesium sulfate, 2.23 g. STEM and 1.11 g. Fe 330 iron chelate per 100 liters.

Both of these formulas are calculated to supply 150 ppm N, 50 ppm P_2O_5 and 100 ppm K_2O.

It is our conclusion that hydroponic fertilization is a very effective method of growing woody plants in containers and that it can be an economical method if waste can be minimized by such means as crowding, individual emitters, or early season use

in conjunction with top dressing. It also has potential uses during the propagation and liner production phases of woody plant production.

MY METHOD OF GROUND COVER PROPAGATION

BOB GRIMES

Warrior Nursery
Rt. 3, Box 782
Warrior, Alabama 35180

In propagating ground covers we are speaking of large quantities. In order to propagate these plants in quantity, plenty of "wood" is needed. Since all of our plants are either from vegetative propagation or division, we must have stock plant facilities.

Our stock plants are grown in 1-gal plastic containers, on approximately 1 A of treated ground covered with 1 to 2 inches of slag gravel, ⅛ to ¼ inch in size. We use #25 impulse-type sprinklers on 30-ft centers with 160 lb city water pressure. This area is treated twice a year with Ronstar (oxadiazone, Rhone-Poulenc) at the recommended rate.

Our spraying program consists of Spectracide (diazinon, Ciba-Geigy) and Docide 101 (copper hydroxide, Kennecot Copper), alternating with Daconil 2787 (chlorothalonil, Diamond-Shamrock) and Orthene 75% WP (acephate, Chevron). We spray about every 30 days, using a 100 gal Mighty Mac trailer-type sprayer with 40 to 50 lb pressure.

In order to maintain weed-free plants we utilize Ronstar at manufacturer's recommended rates. Right after the containers are planted. Ronstar is broadcast over the entire container and plant pad. Application is repeated in late summer and early spring. Roundup (glyphosate, Monsanto) is used throughout the growing season when needed on areas adjacent to the growing pad but not on the container material. It is not necessary to spend any money for hand weeding when we follow this herbicide program.

During the growing season, usually from March through November, we fertilize with a dry top dress of 12-6-6 fertilizer that has been liquid coated with 1% Di-Syston (disulfoton, Mobay Chem.). We apply 1 teaspoon by hand to each container approximately every 60 days or more often during seasons of heavy rainfall, immediately after taking cuttings. Labor is paid for fertilizing on a piece-work basis.

We propagate 12 months out of the year; however, from June to September is our heaviest workload. We take cuttings approxi-

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mately 4 inches in length Cuttings of most cultivars are stuck in trays with the exact count per tray varying with the particular plant. For example, we put 100 English ivy per tray, 150 cotoneaster, and 80 juniper. We use cell packs consisting of 96 individual cells on creeping fig, azaleas, and creeping phlox. Somehow, with use, these just do better in the cell pack. We have a standing order with a West Coast nursery for 50 lb ivy per week. We know within 10 cuttings per week how many we will make. Since labor is paid by the piece, we have a very accurate way of determining our cost per plant.

At present we are predipping thrift, or creeping phlox, and juniper cuttings in a solution of WiltPruf, 1 tablespoon per gal of water. Our rooting hormone on everything is Chloromone (a plant extract, Chloromone Co.) using 1 part Chloromone to 3 parts water. Baby food jars make excellent containers for this solution. We use a rooting medium of ½ fine bark and ½ coarse perlite.

Once these cuttings are stuck, they are transported to mist houses on flat carriers made from worn out, discarded wheelbarrows. They are made to hold five flats, which are color-coded, since the people doing the sticking are on piece-work.

These trays are placed under 47% shaded quonset pipe houses with fine gravel floors. These houses have a 36 inch-side curtain that can be raised or lowered in order to have, or not to have, air draft. We find air is our best fungicide. Five-minute cycle timers active for 3 seconds are used until the first sign of roots appear. The cuttings are then placed on manually-controlled intervals. We use chlorinated city water, which has about 160 lbs pressure. This high pressure gives a very fine mist from the Flora-mist nozzles.

Some of these rooted cuttings are sold in trays, others are potted into 2¼ inch or 3¼ inch pots. As the potting cycle progresses, we shift 2¼ inch pots to gallons for future stock plants and finally the market. The houses hold 900 trays, and those used for ivy are filled and emptied 4 times a year.

A Bouldin-Lawson soil mixer utilizing a bi-level terrain situation works out well. The mixer is on one level, with the potting level 3 ft lower. Our soil mix consists of 3 parts pine bark, 1 part sand, and 1 part Birmingham slate. To each cubic yard we add 10 lb of Sta-Green Pro-Start and 10 lb of dolomite lime, along with 5 oz Banrot, and 5 oz of 10% chlordane. Pro-Start is a potting soil fertilizer mix containing gypsum, superphosphate, urea formaldehyde, potassium nitrate, and micronutrients.

By using a Bouldin-Lawson flat filler attached to the soil mixer on the upper level, we convert this to a 1-gallon can filler. The surplus soil is carried over to a spare potting bench by a

conveyor placed under the lip of the flat filler. We handle the potting setup with a work force of 5 people.

The potting operation takes place under a shed having two trailers located at right angles to the conveyor. When one trailer is filled and off to the field or shade house, the other trailer is in place, never leaving the potting crew without a place to set the freshly-planted containers. Here again, the potting crew are on piece-work.

As previously mentioned, the open field pads for gallon containers are treated with Ronstar. By broadcasting when the fresh containers are placed in growing position, the plants plus the area are treated in one operation. The quonset shade houses are handled in the same manner.

The houses are covered before winter with a single layer 4 mil plastic on top and sides. The exceptionally young liners are heated with gas-fired Modine heaters holding a 40°F temperature. During the winter we add middle benches to all liner houses. These are portable pipe benches made of metal tubing and prefabricated to fit in "boots" that also support the ground-bench side boards. This increases our space to one-third more and helps keep the houses warmer. The field container plants are winterized by placing them can-to-can.

Proper watering is the paramount duty of the entire operation. All water lines, regardless of whether using sprinklers or mist, are installed with 24-volt electric valves with a manual by-pass for times when automatic control is not desired. I would like to point out that this is class II wiring and requires no electrical inspection.

The watering system for the 3¼ inch pots is a homemade device consisting of a plastic container from any discount store, a 24-volt heater transformer from any local supply house, several switches from Radio Shack and a lawn sprinkler control from W.W. Grainger. This control can be varied from 5 to 60 minutes. The importance of proper watering cannot be overemphasized.

In summary of our operation, please keep this in mind:

A We are located within the city limits of a small town in North Alabama (zone 7-8). We operate on 2¼ A in a residential section, utilizing subdivision property that was rejected for residential dwellings. We are on city water.

B. We employ no full time help, but hire mothers with school children and teen-age students on a part-time basis.

C. 90% of our production is by piece-work.

D. We determine our market before production of our plants. We believe it is not necessary to be big, but it is important

to be satisfied with your own operation and the plants you produce.

MY METHOD OF GROUND COVER PROPAGATION

REX MCDONALD
McDonald's Nursery
Route 1
Cameron, North Carolina 28326

McDonald's Nursery is located near Cameron, North Carolina, a small town in the central part of the state. It is in zone 8, which has an annual minimum temperature of 10 to 20°F and high temperatures of approximately 100°F The nursery was started in 1972 as a wholesale operation specializing in groundcovers, and it is a little more than an acre in size.

In recent years, plants which could be used in special locations or to take the place of grass have been in demand due to a desire to reduce maintenance costs. Landscape architects are specifying groundcovers for problem areas such as banks, dense shade, or other unusual areas.

As the nursery is a small one and has no full time workers other than myself, any labor-saving techniques that can be used in a small scale operation must be used. Perhaps the best example of such a labor-saving device is a machine which cuts vine-like plants such as ivy and euonymus into cuttings of 3¼ inch long This machine has 2 electric motors One powers 11 saws spaced 3¼ inch apart at 10,000 rpm, and the second, a slow speed motor, turns 2 sets of belts in such a way that the plant material is slowly fed into the gang saws and the cuttings then dumped at the rear of the machine. This machine can make around 10,000 cuttings in about 15 minutes, provide the material has small stems and is fed into the machine rapidly. It is important that the material is fed into the machine so that it is perfectly straight and perpendicular to the saw. This machine was developed by Ernest Cuzzocreo of Orange, Connecticut, in cooperation with the University of Connecticut.

Another labor-saving technique that was recently started here is to market plants as rooted cuttings, bare-root, or as divisions instead of attempting to pot each plant in an individual pot as was practiced until last year. These practices allow more plants to be produced in a shorter time and in a smaller area. Since an established root system is preferred by some landscapers, many plants must still be produced in individual pots

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However, we hope to reduce the number from our present 50% of total production.

At present, cultivars of the following species are grown:

Ajuga reptans	4 cultivars
Euonymus fortunei	1 cultivar
Hedera helix	4 cultivars
Liriope	3 cultivars
Ophiopogon	1 cultivar
Pachysandra	1 cultivar
Phlox subulata	5 cultivars
Vinca minor	1 cultivar
Cortaderia selloana	1 cultivar

Euonymus, ivy, pachysandra, and phlox are all propagated from cuttings This propagation begins in outdoor beds in early May and continues until September *Euonymus fortunei 'Coloratai'* taken in August is well-rooted and has good new growth by October.

The beds are 60 feet long and 5 feet wide. The sides are constructed of 4 inch concrete blocks (2 rows high). The bed has 4 inches of coarse gravel at the base covered by 2 inches of coarse sand over which the rooting medium of 50% perlite and 50% pine bark is placed about 4 to 6 inches deep. The pine bark will pass through a ¼ inch screen. Pine bark is used in place of peat as it is readily available in this area and seems to give better drainage and better root development. Two rows of alternating mist nozzles are spaced 6 inches from the sides of the bed. The nozzles are Flora-mist type spaced 30 inches apart in each row and about 12 inches above the rooting medium. A misting interval of 6 seconds every 2 minutes is used in early summer for ivy, *Hedera helix*, *Euonymus*, and *Pachysandra*. In late summer an interval of 6 seconds every 6 minutes is used for the phlox as it rots under moist conditions.

The beds are sterilized with methyl bromide in the early spring and each crop of cuttings is drenched with fermate. These beds are located in full sun, which seems to make cuttings hardier when they are potted and placed under field conditions in beds. Additional 4-inch blocks are placed on sides around the top of the bed to prevent the wind from blowing the mist away from the plants.

Ivy and euonymus, which are sold as rooted cuttings, are propagated in trays containing a mixture of 3 parts pine bark and 1 part fine sand (builder's sand) with 12 lb. lime and 6 lb. supersphosphate added per cu yd of mix. These plants are placed in a ground bed with one line of mist nozzles running down the center of the bed. The nozzles are spaced 3 ft apart on risers that are 15 inches above the trays. A mist interval of 10 seconds every

6 minutes is used. The bed is covered with sections of welded wire to form a quonset, which is then covered with opaque plastic. Holes are cut in each end of the tent and over each mist nozzle for ventilation. This arrangement also enables the nozzles to be checked more easily. Some nurseries use clear plastic but in our area it allows too much light and too much heat buildup for the plants to root satisfactorily.

We plan to try producing *Ajuga* 'Burgandy Glow; in trays and market it as we do euonymus and ivy. Ajuga, liriope, and mondo grass (*Ophiopogon*) are propagated by divisions. Vinca is propagated from rooted plants taken out of beds. It is put into 3 inch pots and is salable in about 6 weeks. Pampas grass is propagated by seed

Our medium for most potted plants is a standard mixture of 3 parts well-rotted pine bark and 1 part fine sand (builder's sand) to which 10 lbs of Pro-Start, 7 lbs 14-14-14 Osmocote, and 12 lbs dolomitic lime/yd^3 is added. Pro-Start is a potting soil fertilizer mix containing gypsum, superphosphate, urea formaldehyde, potassium nitrate and micronutrients. The 8 to 9 month Osmocote formulation is used for liriope and mondo grass.

After potting, the plants are placed on black plastic in rows in the nursery. These newly-potted plants are watered lightly 3 or 4 times daily for 2 days after which they receive water daily from an overhead irrigation system. All plants are topdressed with 38% urea in June. Weeds are controlled with Ronstar (oxadiazon, Rhone-Poulenc), 2 lbs/1,000 ft^2, on all plants except ajuga. I plan to use Treflan (trifluralin, Elanco) in conjunction with Ronstar next year to control spotted spurge. Walkways are kept in grass and are mowed. We use Roundup (glyphosate, Monsanto) to maintain weed-free borders around all plant areas.

Winter protection must be provided for ivy, ajuga, and mondo grass. This protection is accomplished by using ¼ inch thick microfoam on the ivy and mondo and by building a small quonset structure over the ajuga beds which are covered and sealed with opaque plastic in late November.

I attempt to produce and sell plants in 6 months or less, except for liriope and mondo which take longer It is possible to do so by giving careful attention to the details I have described.

MY METHOD OF PROPAGATING GROUND COVERS

E. F. DUBOSE

3112 Triana Blvd.
Huntsville, Alabama

This wholesale nursery is composed of 10 acres of land on which we have coldframe-hotbed combinations. We have our stock-blocks to furnish wood for evergreen and deciduous liners in addition to ground covers. Propagating beds are mostly 6 ft by 15 ft, covered with 3 ft by 6 ft hotbed sash. Frames are made from 2 inch by 12 inch by 16 ft pressurized-treated lumber. Frames are set about 6 inches in the ground, sloping to the south, and carved out beyond 6 inches to an average total depth of 18 in. To this we add 6 or 7 in. of coarse sand and 6 cubic ft of peat the first year we use the bed. We add 3 cubic ft of peat each year thereafter.

This nursery was first certified by the state in 1934. At that time I didn't see anything like a mist system around. We watered with a 3- or 4-inch sprinkler heads on a regular hose and still do. A *mist system is not appropriate as the beds would soon have too* much water. Since our frames are partly in the ground there is no way for the water to drain.

Since our physical set-up is so different from the mist system, we rarely get any practical help suggestions on propagating from other nurserymen or find professional books on this subject. Our methods have been mostly "trial and error." Naturally we have had to do quite a bit of experimenting with such factors as when the wood is ready, how much watering is needed, and how much heat a cutting can take in closed beds

We propagate only 3 cultivars of ground covers. I will discuss these one by one as each is very different from the others in its propagation requirements.

Ajuga. Our ajuga is grown in the field. In the fall we dig clumps, divide into individual plants, dip in a fungicide if need be and simply set these out in a newly rotated area to grow for the next season. Our ajuga mostly grows in open field rows. We set some in the stock blocks under larger plants, such as *Ilex cornuta* 'Burfordii' and *Ilex cornuta* 'Rotunda'. We find the partial shade helps out quite a bit in hot and dry weather. Plants do well in this partial shade. I may add, the ones grown in rows are cultivated. To date we have found no completely satisfactory herbicide, however, Treflan (trifluralin, Elanco) looks promising.

English ivy. We have a permanent English ivy stock block that produces all the wood we use for cuttings. this stock block is well cared for to be sure we have a good supply of strong

cuttings. This block is kept about 90% free of grass and weeds by use of a granular herbicide applied sometime in the early spring and again in the early fall as needed. This stock block is not cultivated. We go through it with a hoe to get any weeds that may escape the herbicide. We spray for possible fungus and insects as needed. The block is fertilized in early spring and again in early summer in order to keep up a growth of wood.

The propagators cut a few ivy vines and take to the inside work benches. These vines are dipped in a tub of water that may or may not have fungicide in it. They are cut into 5- to 7-inch pieces, the lower 2 or 3 leaves stripped and the base end of the stem dipped into a #2 Hormodin (0.3% IBA, Merck). This leaves 2 or 3 leaves to help produce a nicely-rooted plant.

Now the cuttings are stuck into a cut trench made with a common 6-inch-trowel blade and a hardwood stick as a guide. Cuttings are placed in approximately 2-inch rows, the sand packed thoroughly, cuttings watered well, and the bed covered with shaded sash.

These beds are kept closed until the cuttings begin to root. They are kept well-watered the first 2 or 3 times and thereafter misted or syringed 2 to 4 times a day, all depending on outside temperature and moisture If it is a rainy day, we may water less. This is judged by whether water from previous waterings is still quite noticeable on the foliage.

Our ivy propagation is done mostly in October, November, and December. As it grows cooler at night, we gradually drop watering from 3 to 4 times a day to 2 times a day. As roots appear, we reduce watering to 2 times a day and then to one time After roots are well formed we start ventilation and gradually reduce watering from once a day to every several days.

Some years in the past we started ivy propagation in August. We got poor results; we were only getting 20 to 25% rooted plants. We decided maybe our type of beds got too hot at that season for several cultivars of plants and maybe ivy was one of these.

We decided maybe it got too hot in closed beds, so we started ventilating a bit to let out the extremely hot air as soon as we set out a bed. We used the same watering procedure as discussed earlier. As roots started to appear we gave a little more ventilation. This resulted in a 50% plant survival.

The above experiment led us to change our propagating to October, November, and December. We water as explained but do not ventilate. Our present results of nicely rooted plants now stands around 90%.

Euonymus 'Colorata'. The third and last ground cover we

propagate is *Euonymus fortunei* 'Colorata'. We find this plant does well in the open, sunny places as well as partial shaded places.

Our stock block is composed of several long rows out in the sun. Instead of cultivating we use granular herbicide applied once or twice a year. We also use systemic granular chemicals for scale at least twice during the growing season. We find scale is the #1 enemy of most all euonymus but especially *E.* 'Colorata'.

Our stock block is cut over systematically several times a year. After each heavy cutting we apply a granular fertilizer on the surface. In dry weather we turn the irrigation on to help get the fertilizer to the roots quicker. All fertilizing is done from early spring through late summer.

We start making cuttings from new and tender wood about late April or early May. For the first several weeks we pull these cuttings off by hand. When they get tougher, we cut them off for the rest of the season.

The cuttings are dipped in plain water unless we see signs of insects or fungus. Then we apply chemicals. The wood is then brought to the work bench and cut in desired lengths. The lower two inches are stripped of foliage and dipped in #2 Hormodin (0.3% IBA)

These cuttings are set about an inch into the medium in rows 2 inches apart. They are watered quite well 2 or 3 times the first 1 or 2 days, then syringed 2 to 4 times a day thereafter until rooting starts. Two or 3 weeks are required in the spring and summer for rooting but longer in the fall.

As a rule watering is cut to twice a day after the first 10 to 14 days. As roots start nicely, we cut watering to once a day and start ventilation on a small scale, increasing it every 5 to 7 days by degrees. In 6 or 8 weeks these rooted plants are ready for potting or planting on the job.

Our results in rooting tender or some hardier plants are approximately the same — one just takes a bit longer. We propagate *Euonymus fortunei* 'Coloráta' the whole year (12 months). Our rooting percentage is usually good, about 90%, all the time if cuttings are properly set out.

SOURCES OF INFORMATION

We have been experimenting and propagating plants since the early 1930's. The reference I found then and for some years to come was Fritz Bahr's *Commercial Floriculture.*

The past decade or so I found helpful ideas from *Plant Propagation, Principles and Practices,* all editions, by Hudson T.

Hartmann and Dale E. Kester. Also, *Plant Propagation Practices* by James S. Wells. As stated before, I seem to get no direct instructions from any of these authors or from other books I have read. However, they are a big help because they helped create practices we do use.

Locally, over the early years I got some most valuable suggestions and help from successful propagators such as Chase Nursery Company, Byers Nursery Company, Huntsville Wholesale Nursery, and Rodenhauser Florist.

REFERENCES

1 Hartmann, Hudson T and Dale E Kester 1975 *Plant Propagation Principles and Practices* 3rd ed Englewood Cliffs, New Jersey Prentice-Hall

2 Wells, James S 1955 *Plant Propagation Practices* New York The Macmillan Co

GROWING TREES FOR INTERIOR USE

RICHARD W. HENLEY

Agricultural Research Center
University of Florida
Route 3, Box 580
Apopka, Florida 32703

Interior trees can be defined as tropical or semitropical plants with evergreen foliage, woody, predominantly upright stems which are approximately three feet or more in length. Most interior trees have prominent branching structure including plants with single stems, branched trunks or multiple stems from the base and are well adapted to the light level, humidity and temperature regimes inside buildings maintained for human comfort. Several unique aspects of producing interior trees are discussed in this paper. Cultural practices are those commonly used by Florida nurserymen in southern and central regions of the state. Nurseries located in Dade, Palm Beach, and Broward counties, the southeastern region Florida, account for most of the interior tree production, with limited production in southwest and central Florida.

Interior tree production on a massive commercial scale is a relatively new industry when contrasted to the landscape tree business. Most interior tree nurseries in Florida have developed within the last twelve years, making it one of the fastest growing segments of commercial horticulture. Present rate of expansion is much less than recorded during the early 1970's.

Just as landscape plants must be evaluated for adaptability to

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Interior trees can be defined as tropical or semitropical plants with evergreen foliage, woody, predominantly upright stems which are approximately three feet or more in length. Most interior trees have prominent branching structure including plants with single stems, branched trunks or multiple stems from the base and are well adapted to the light level, humidity and temperature regimes inside buildings maintained for human comfort. Several unique aspects of producing interior trees are discussed in this paper. Cultural practices are those commonly used by Florida nurserymen in southern and central regions of the state. Nurseries located in Dade, Palm Beach, and Broward counties, the southeastern region Florida, account for most of the interior tree production, with limited production in southwest and central Florida.

Interior tree production on a massive commercial scale is a relatively new industry when contrasted to the landscape tree business. Most interior tree nurseries in Florida have developed within the last twelve years, making it one of the fastest growing segments of commercial horticulture. Present rate of expansion is much less than recorded during the early 1970's.

Just as landscape plants must be evaluated for adaptability to

regional factors such as temperature, soil type, rainfall, pathogens, insects, nematodes, other pests, and maintenance requirements, interior trees must also be evaluated for their ability to adapt to indoor locations which have light levels of 50 to 150 foot candles, relative humidities of 10 to 30 percent, and temperatures betwen 55 and 80°F.

Interior trees are produced in a wide range of sizes depending upon where the plants will be used. Trees used in residential and office interiors usually are available in 8- to 12-inch diameter containers while large scale commercial or institutional buildings may require plants in containers up to 200-gallon capacity. Specifications for interior trees were initially developed and published by the Florida Foliage Association (4) and later expanded by Associated Landscape Contractors of America (1). Table 1 lists 24 of the major interior tree species and cultivars with container diameter range produced.

Table 1. Major interior tree species available in Florida [z]

Plant[y]	Container size[x]
Araucaria heterophylla	6 - 17-inch
Beaucarnea recurvata	6- inch - 30-gallon
Brassaia actinophylla	5-inch - 30-gallon
Chamaedorea erumpens	6 - 17-inch
Chamaedorea seifrizii	6-inch - 20-gallon
Chrysalidocarpus lutescens	6-inch - 40-gallon
Clusia rosea	6 - 14-inch
Dizygotheca elegantissima	6 - 17-inch
Dracaena deremensis 'Janet Craig' and 'Warneckii'	6 - 17-inch
Dracaena fragrans 'Massangeana'	6-inch - 20-gallon
Dracaena marginata	6-inch - 20-gallon
Dracaena reflexa	6 - 17-inch
Ficus benjamina (F nitida[1]*)*	6-inch - 95-gallon
Ficus benjamina var benjamina (F benjamina)	6-inch - 200-gallon
Ficus elastica 'Decora' and 'Decora' types	6-inch - 20-gallon
Ficus lyrata	6 - 14-inch
Ficus triangularis	6-inch - 10-gallon
Podocarpus macrophyllus	6-inch - 40-gallon
Polyscias balfouriana 'Marginata'	6 - 14-inch
Polyscias fruticosa	6-inch - 35-gallon
Rhapis excelsa	10 - 21-inch
Schefflera arboricola	6 - 14-inch
Yucca elephantipes	6 - 17-inch

[z] Adapted from *Florida Foliage Buyers Guide* (2).
[y] Plant names listed according to *Hortus Third* (3)
[x] Several plants listed are available in container sizes smaller than 6-inch diameter

[1] Bot Ed note *Ficus nitida* in U S trade is often *F microcarpa*

Propagation of interior trees is done by a variety of techniques depending upon species or cultivar, amount of stock available, economic factors relating to cost of propagule, size of propagule desired, production schedule, and size of finished plant. Table 2 indicates some of the techniques which are used for commercial propagation of interior trees. Trends in propagation observed in recent years include: (1) use of tissue culture for a few interior trees, (2) use of larger air layers (up to 5 feet in length with some species), (3) a shift of stock production from southern Florida to Central America, South America, and the Caribbean Islands where the climate is nearly ideal and labor costs are low, and (4) improved nutrition of stock plant cuttings and layers

Within the past eight years cultural recommendations for interior tree production have changed considerably as the result of University of Florida research on factors required for foliage acclimatization. The term acclimatization is synonymous with conditioning and acclimation used by other authors. Trees in foliage nurseries are grown under light levels and fertilizer regimes many times that which they will be subjected to when

Table 2. Means of propagating selected interior tree species and cultivars commercially

Plant[z]	Propagation techniques[y]						
	Seeds	Terminal cuttings	Single or Multi node cuttings	Cane cuttings	Air layers	Divisions	Tissue Culture
Araucaria heterophylla	A	C	—	—	C	—	—
Beaucarnea recurvata	A	C	—	C	C	—	—
Brassaia actinophylla	A	C	C	—	C	—	B
Clusia rosea	A	A	—	—	C	—	—
Chamaedorea erumpens	A	—	—	—	—	C	—
Chamaedorea seifrizii	A	—	—	—	—	C	—
Chrysalidocarpus lutescens	A	—	—	—	—	—	—
Cizygotheca elegantissima	A	B	C	—	C	—	—
Cracaena deremensis 'Janet Craig' and 'Warneckii'	—	A	C	A	C	—	—
Dracaena fragrans 'Massangeana'	—	A	C	A	C	—	—
Cracaena marginata	—	A	C	B	A	—	—
Dracaena reflexa	—	A	C	C	B	—	—
Ficus benjamina (F nitida)	—	A	B	—	A	—	—
Ficus benjamina var benjamina (F benjamina)	—	A	C	—	A	—	B
Ficus elastica 'Decora' and other 'Decora' types	—	B	C	—	A	—	B
Ficus lyrata	—	C	B	—	A	—	—
Ficus triangularis	—	A	C	—	B	—	—
Podocarpus macrophyllus	A	B	C	—	C	—	—
Polyscias balfouriana 'Massangeana'	—	A	A	B	C	—	—
Polyscias fruticosa	—	A	A	B	C	—	—
Rhapis excelsa	—	—	—	—	—	A	—
Schefflera arboricola	A	A	A	—	A	—	—
Yucca elephantipes	C	A	C	A	C	—	B

[z] Plants listed according to *Hortus Third* (3)

[y] A = a major commercial technique, B = a minor commercial technique, C = a technique not significant commercially

installed indoors. The objective of producers is to make the transition of plants from the nursery to the interiorscape as stress-free as possible. Table 3 lists the suggested light intensities and fertilizer rates for production of acclimatized, container-grown, interior trees.

Another factor influencing acclimatization of interior trees is establishment of roots in the soil mixture of the finished plant. Fully established trees will have a root system extending to the bottom and lower portion of the container side wall at which point they twine. Without this degree of root development, plants should not be regarded as fully acclimatized because they lack the desired balance of roots and shoots.

In some instances large specimen trees are grown in the ground under full sun conditions until close to the desired size, leaving the remaining time to be containerized in a high quality

Table 3. Suggested light intensity ranges and fertilizer application rates for production of some interior trees

Plant[z]	Light intensity[y] (foot-candles)	Nitrogen rate[x] (lbs/1000 sq ft/yr)[y]
Araucaria heterophylla	4000-8000	28
Beaucarnea recurvata	4000-8000	28
Brassaia actinophylla	400-6000	41
Clusia rosea	3000-6000	34
Chamaedorea erumpens	3000-6000	28
Chamaedorea seifrizii	3000-6000	28
Chrysalidocarpus lutescens	4000-6000	34
Dizygotheca elegantissima	4000-6000	28
Dracaena deremensis 'Janet Craig'	2000-3500	28
Dracaena fragrans 'Massangeana'	2000-3500	28
Dracaena marginata	4000-6000	41
Ficus benjamina (F nitida)	3000-6000	41
Ficus benjamina var benjamina (F benjamina)	3000-6000	41
Ficus elastica 'Decora' and 'Decora' types	6000-8000	41
Ficus lyrata	4000-5000	41
Ficus triangularis	3000-6000	41
Podocarpus macrophyllis	3500-4500	28
Polyscias species and cultivars	1500-4500	41
Rhapis excelsa	3000-6000	28
Schefflera arboricola	4000-6000	41
Yucca elephantipes	3500-4500	28

[z] Plant names listed according to *Hortus Third* (3)

[y] *Araucaria, Ficus benjamina benjamina, Ficus retusa, Podocarpus* and *Rhapis* are frequently grown under full sun light levels (8000-15000 foot-candles) and then placed under suggested light intensity for final 3-month period

[x] P_2O_5 and K_2O rates should be computed on basis of a 3-1-2 fertilizer ratio for long term fertilization programs P_2O_5 and K_2O rates may be increased up to but should not exceeding a 1 1 1 ratio for starting crops or crops not exceeding 8 weeks in production

soil mixture, established and fully acclimatized under the light and fertilizer programs shown in Table 3.

Soils are an important consideration in both production and utilization of interior trees. Presently most soil mixtures formulated for container-grown interior trees consist of 60 percent or more organic particles (high quality fibrous peat, pine bark, etc.) and the remaining portion being inorganic materials (coarse sand, calcined clay, perlite, vermiculite, styrofoam shreds or beads, etc.). Particles such as pine bark, calcined clay, and perlite tend to open the soil mix and provide good drainage and aeration. The primary function of sand is to increase the weight of the mix so the trees will be less likely to be blown over by wind. Durability of the large particles placed in soil mixes used for tree production is important. Interior trees should be grown in the most durable combination of components possible because they are the longest lived and most expensive of all foliage plants. Ideally the soils for interior trees should have certain ranges of chemical and physical characteristics (Table 4).

Table 4. Suggested chemical and physical characteristics for container-grown interior trees

Characteristic	*Suggested range*
pH	5 5 - 6 8
Salinity (Soluble salts)	200 - 800 ppm (indoors)
Bulk density	40 - 60 g/cm^3
Free pore space	8 - 20 percent (by volume)
Water holding capacity	20 - 40 percent (by volume)
Cation exchange capacity	5 - 25 meq/100 cm^3

Interior trees should have nearly perfect leaves with regard to mechanical damage, pest damage, or foliage residues. To achieve this degree of perfection nurserymen must avoid wind damage by shielding plants from wind or properly staking, bracing or guying tall plants exposed to wind. Plants which are blown over are usually damaged mechanically and very vulnerable to sunscald. Plants should also be handled carefully as they are moved within the nursery and especially during packaging or wrapping and transportation stages. Rigid pest control and monitoring programs are needed throughout the crop cycle. Avoid extensive use of wettable powder pesticide formulations which leave unsightly residues and use overhead water sources low in dissolved carbonates and iron.

Shipping is an important and usually expensive portion of the total plant cost to consumers. Unlike many plant products foliage plants have rather narrow tolerances with regard to physical, chemical and biological stress factors during shipment. Plants should be packaged and supported in a manner which protects them from being crushed or torn during shipment. The

normal shipping temperatures for tropical foliage plants are 60° to 70°F, achieved by specially designed trailers or trucks with the capability of heating, cooling, and circulating air around the cartons or plants. Special consideration should be given to protect plants from temperature extremes as they are moved to and from the trailers or trucks. Care should also be taken to avoid exposing plants to ethylene gas levels exceeding 1 ppm. Ethylene injury is dependent upon ethylene concentration around the plant, exposure duration, and temperature.

A very thorough discussion of commercial culture of foliage plants, including interior trees, is provided in *Foliage Plant Production* (5)

LITERATURE CITED

1 Anonymous 1979 *A Guide to Specifications for Interior Landscaping*, second edition Associated Landscape Contractors of America, Interior Landscape Division McLean, Virginia pp 56

2 Anonymous 1980 *The Florida Foliage Buyer's Guide* Florida Foliage Association Apopka, Florida pp 180

3 Bailey, L H Hortorium, Staff of the 1976 *Hortus Third* Macmillan Publishing Company, Inc New York, New York pp 1290

4 Gaines, Richard L 1977 *Guidelines for Foliage Plant Specifications for Interior Use* Florida Foliage Association, Apopka, Florida, pp 36

5 Joiner, Jasper N (Editor) 1981 *Foliage Plant Production* Prentice-Hall, Inc, Englewood Cliffs, New Jersey pp 614

QUESTION BOX

The Southern Region Question Box was moderated by Richard Ammon and Ted Richardson

LES CLAY: We are working with tissue culture of rhododendron and kalmia using IAA (3-indoleacetic acid). Has anyone tried using 2,4-D or 2,4,5-T in tissue culture preparations? We have a problem getting a complete plant when tissue culturing kalmia.

FRANK BLAZICH: The usual auxin is NAA (1-naphthaleneacetic acid).

HENRY VAN DER STAAY: You can use IAA or NAA, depending on what results you want and what species you are using; 2,4-D induces callus formation, and you may then have trouble getting a complete plant.

LES CLAY: We are using IAA in agar with kalmia and rhododendron and are then taking the explants from agar to the medium. We use sand, soil, peat and perlite for the rhododendron. However, this mix is not satisfactory for the kalmia, but instead we have found that a mix of peat and sand is better. We

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make no further hormone application, as there seems to be a carry-over effect. The cuttings root in 3 to 4 weeks. We get about 80% rooting. We would like to mix the hormone in the original medium.

FRANK BLAZICH: I believe 2,4-D and 2,4,5-T have been used to encourage the formation of callus, but I have no information on their use in tissue culture to promote rooting.

JAKE TINGA: It is essential to recognize the importance of concentration differences when these materials are used as herbicides and when they are used as rooting hormones. The concentrations for herbicide use are much higher. Another important point to recognize is the effect of water concentration on callus formation. Callus formation occurs in cases where there is too much water and too little air. Usually the mix is the problem, and this is also true in tissue culture. The metabolic rate is very high in both cases, and a continuous high level of oxygen must be maintained.

DAVID BYERS: Is there a good herbicide to use on bearing strawberries?

DAN WEATHERSPOON: Devrinol (napropamide, Stauffer) is a possibility.

BRYSON JAMES: Dacthal (DCPA, Diamond-Shamrock) is about the only one that is registered for this purpose.

RALPH SHUGERT: Dacthal is an old herbicide but is the safest. It is marketed in many forms. It is even safe on seedlings if the true leaves have formed. However, if it is applied before that time, the seedlings will be killed. The material should be used at 30 day intervals. Dacthal mainly controls grasses and should be applied before emergence. A final application in October will actually save money in April and May. Even though effectiveness is considered to last for only 30 to 40 days, there will be a considerable carry-over effect the following spring.

DAVE BYERS: I have been asked about the cost of our new refrigerated storage building without including the cost of the refrigeration The building itself, which is 5,000 square feet, cost $36,000.

There has also been a question about the cost of the sprayer that we use for application of all herbicides and insecticides. The sprayer is a Hardi, manufactured in Denmark. It sells for about $5,000 cash. Additional information on the sprayer can be obtained from Bryson James, McMinnville, Tennessee.

RALPH SHUGERT: I am interested in comments on the relative merits of 'Blue Pacific' and 'Emerald Sea' cultivars of *Juniperus conferta*, shore juniper.

JIM GILBERT: We obtained cuttings of 'Emerald Sea' from

USDA and now have 2-year old plants. So far we can see little difference except that the 'Blue Pacific' is slightly darker.

SUSIE GILBERT: It is very difficult to tell 'Emerald Sea' from the species when the plants are in containers. However, they may look different when planted out into the landscape.

RICHARD AMMON: What about its hardiness? We have never been able to grow *Juniperus conferta* in our area but have been able to grow 'Blue Pacific.'

JIM GILBERT: The 'Emerald Sea' does seem to be a little hardier than the species

RALPH SHUBERT: I believe it was collected by Mr. John Creech on one of the Pacific Islands while he was working for the USDA. It was evaluated, named and released by the SCS of USDA from their location at Cap May, New Jersey. It is hardy there. Does it grow off any faster than 'Blue Pacific,' and is it subject to phomopsis?

JIM GILBERT: It does grow faster. We have not as yet had trouble with phomopsis.

AL SCHERFF: Propagators often have trouble with rodents in their seedbeds, and the question was asked as to a solution. We have found the use of Temik (aldicarb, Union Carbide) very effective.

JUDSON GERMANY: Is anyone in the group propagating ferns? We have a demand for these plants but very few that will perform satisfactorily in our Ft. Worth area. I am interested in trying to propagate different ones to test in our climate.

BILL CURTIS: We propagate a fern that is commonly known as the Alaska fern. This species forms plantlets along the midrib of the frond. We simply pin down the fronds in a flat of sand and peat until the plantlets form roots. We then cut the frond into pieces and pot the rooted plantlets.

RALPH SHUGERT: In the 1978 Proceedings there are step-by-step details in a paper presented by Ray Aitken of the Australian region (1)

HENRY VAN DER STAAY: We use Jiffy 7's as a top dressing for flats of peat-perlite. We soak these overnight, remove the bags and break the pellet up into fine particles. Everything must be very sanitary for spore propagation. We use boiling water to sanitize all equipment and also use boiled water to water the flats and plantlets. Spores are collected by putting the fertile fronds in a paper bag just before the sori are ready to open. When they have dried, the spores will fall out of the sori into the bottom of the bag. Most of these spores will store indefinitely under proper storage conditions We distribute the spores on top of the flats, then cover them with glass. We maintain a tempera-

ture of about 70°F. It takes about 8 to 10 days for maidenhair spores to germinate but much longer for many others. The first growth has the appearance of fine moss. It is not possible to water these flats successfully overhead; they must be subirrigated. After 4 to 6 weeks the plantlets are transferred to a tray on approximately 1½ inch centers. The plants will be transplanted at least once more before they are ready for sale. Early spring is a good time to begin propagation. If spores are sown in the winter, extra light is necessary to provide a 16 hour day. We keep the flats heavily shaded and extremely wet to start. We put the flats under a plastic tent to maintain high humidity.

RALPH SHUGERT: Is anyone rooting *Acer rubrum* economically?

RICHARD AMMON: Don Shadow, McMinnville, Tennessee, is doing it with *A. palmatum*.

WILL WITTE: It is being tried in Tennessee. I expect to see more propagation of *Acer rubrum* on its own roots.

RALPH SHUGERT: Much of the 'October Glory' cultivar in the Portland area is being propagated on its own roots, and it seems to be cheaper.

FRANK BLAZICH: An article in the American Nurseryman by Orton describes the rooting of 'October Glory' (2). He used a single-node cutting.

RALPH SHUGERT: I do not believe it would be economical to use a single-node cutting because of the length of time required to attain saleable. size.

LES CLAY: Jim English, Chilliwack, British Columbia, uses a single node for propagation of *Acer rubrum* and gets a 2 to 3 foot plant in 1 year. It is comparable to a 1-year seedling.

RICHARD AMMON: Does he line these out and cut them back to get a straight whip?

LES CLAY: I am not sure on this point, but it is quite possible.

HENRY VAN DER STAAY: Is anyone in the group using solar heating for a glasshouse?

JAKE TINGA: I believe we are expecting too much from solar heating. It takes a tremendous collector and a tremendous storage tank to provide the amounts of heat we expect. The investment at present is uneconomical.

HENRY VAN DER STAAY: I am experimenting with solar heating although I am not quite satisfied with my set-up. I am using a 44 m^2 (about 500 ft^2) corrugated iron collector with copper tubing across the top of the sheet. Free water moves across the face of the collector and accumulates in a gutter below where it

again goes into a copper pipe to be carried into the greenhouse bench We have had no moisture condensation problem except in midwinter. The collector has 4 inches of rockwool insulation behind it and glass over the top. The iron costs $10 per m^2. The water is used to heat a 40 by 6 foot bench. In a few hours the temperature is up to 100°F. We formerly were relying on oil for 7 or 8 hours each day during the winter and have now been able to reduce this to 1 hour. I would like to be able to store the hot water in a tank and avoid the 100° temperature.

BILL CURTIS: The Klupengers, Aurora, Oregon, are using a solar system in combination with a heat pump. Ray Klupenger, manager of the range, is able to maintain an even 50°F temperature, even though Oregon has few sunny days during winter. They are using the system for forcing evergreen azaleas. Ron Klupenger's address is in the Proceedings.

JAKE TINGA: Although I have had good success using water barrels, research in Ohio reported this as not feasible because the water in the barrels froze. However, a rather large amount of heat is released during the freezing process; and if the temperature of the frozen water is greater than that of the surroundings, heat will still be given off. The water barrels can also be a great safety factor during spring and fall. The best spacing seems to be one 55 gal barrel for each 100 ft^2.

RALPH SHUGERT: I saw this system at the Forest Keeling Nursery, Elsberry, Missouri, during the winter of 1955-56, and it certainly worked then.

AL SCHERFF: We have used the water barrels and were able to hold the temperature in a plastic house at 15°F when it was −18°F outside. In another house without the barrels the temperature dropped to 0°F.

VIVIAN MUNDAY: Do the barrels need to be metal?

AL SCHERFF: No, nor must they be black although this is probably the most efficient

HENRY VAN DER STAAY: I have seen black plastic continuous tubing used for this.

RALPH SHUGERT: Question for Ted Richardson. Have you ever used surfactants for wetting your medium?

TED RICHARDSON: No.

TED GOREAU: Question for Ted Richardson. Will you continue to move your rooted cuttings from North Carolina to Florida for growth during their first winter after rooting?

TED RICHARDSON: Yes, I plan to continue the present system as the extra growth during the winter gives us a 15 to 18 inch plant by the following fall.

GROWTH MANIPULATION OF JUNIPERS

J B FLETCHER

Greenleaf Nursery Co.
Park Hill, Oklahoma

Greenleaf Nursery Company is headquartered approximately 90 miles southeast of Tulsa, Oklahoma, at Park Hill. Our Texas Division is located in South Texas approximately 70 miles southwest of Houston at El Campo. Both nurseries are exclusively producing container-grown ornamentals, growing a broad selection of narrow-leaved and broad-leaved evergreens, trees and shrubs The practical aspects of growth manipulation of junipers presented in this paper will be from experience gained at the Oklahoma site.

Our Oklahoma division is growing 50 cultivars of junipers, offered for sale in 1-, 2-, 5-, and 7-gallon containers. Our juniper crop comprises 58% of our total production.

Growth manipulation of any crop, in this instance, junipers, simply means to operate, manage and control this growth to one's advantage Thus, the growth manipulation of junipers is done to achieve a quality, salable product at a price that is favorable to both the seller and the buyer.

The manipulation of growth starts in the propagation area. We feel that it is essential to reach the container with a high quality liner. To produce this liner, we begin taking our cuttings in early December from plants in our growing area which have another year to grow before sale. These plants have had the proper growing conditions, resulting in vigorous new growth, which aids in our rooting percentage and uniformity.

Our juniper liners are grown in the propagation beds for approximately 1 year before being transplanted bare-root to the container in February and March. The liners are closely graded at the time of digging and graded again during planting to insure that only uniform, healthy liners reach the container.

At this state we need to insure that the basics of good container growing are followed. These basics include the use of suitable containers, media, cultural practices, pruning, spacing, and timing.

Today's containers are mostly plastic of many sizes, shapes, and colors. A container that has adequate drainage, desirable size and durability should be chosen.

The medium used to fill the containers is one of the more important basics, as we all know, when dealing with containerized plants that must develop a root system in a very limited growing volume Our present mix consists of groud pine bark,

sand, ground shale, and fertilizer additives. This is a very porous mix, which allows good drainage but maintains adequate nutrient levels.

Cultural practices that must be followed are proper watering, fertilization, and pest control. Our watering is monitored very closely by our division personnel. Each division supervisor has one person whose sole responsibility is to determine water needs. These people probe each division daily, actually taking soil samples of the medium, determining the water needs for that day, and co-ordinating water placement with the irrigation department In this manner we can accurately water only when needed and in an amount that will not leach needed nutrients out of the container.

Our plant culture department monitors the nutrient levels throughout the growing season. Soil samples are taken weekly on each group of plants, nutrient levels determined, and action taken to insure that maximum levels are maintained. Our fertilization program consists of three separate operations. The first of these is the addition of fertilizers at the time our soil medium is made. The second is a hand application of Osmocote 18-6-12 on all of the 2-year crops after the first growing season. The fertilizer is carefully distributed under the foliage on the surface of the medium. A slow-release nitrogen fertilizer is applied to all salable crops prior to shipment to maintain adequate nutrient levels from the time they leave the nursery until they are permanently planted. The third method of fertilization is done through "fertigation", or the injection of nitrogen, phosphorus, and potassium through our overhead watering system. This is done when our soil tésts show a decline in available nutrients during the growing season.

The successful control of ornamental pests depends on an early and correct diagnosis of the problem. Our pest management program is designed to obtain the utmost in control of the various pests and problems related to insects, diseases, and weeds. Nutrition and irrigation problems are included in this quality control program. The program involves 3 interrelated stages:

1) The presentation of information needed to recognize and report the pests.
2) The collection of data in the form of a field work sheet, filled out each week by the division supervisors.
3) Interpretation of this data into useful information by the plant culture department.

The interpretation of the data collected on the field work sheets includes recognizing specific trends in the occurrence of pests, then setting up time schedules and planning the spray program so we can treat specific pests with specific chemicals at

the proper time. We are then able to cut spraying costs and at the same time achieve better results.

Another step in the growth manipulation of junipers is shearing or pruning. This is done to produce a bushy, well-branched, uniform plant. Our 1- and 2-gallon junipers are sheared a total of 7 times from the time they are taken as a cutting until they reach salable size. First, the cutting is tipped back when it is originally taken for propagating. Then, as liners in the propagation bed, they receive their second and third shearings during the growing season. The fourth shearing is done immediately after the liner is planted in the container. The fifth shearing is done during the middle of the first growing season in the container. Cuttings are taken from this 1-year-old crop between December and March. As soon as the cuttings have been taken, they are sheared for the sixth time. The final shearing is done in June before the plants become salable that fall.

The 5-gallon junipers receive an additional 2 shearings to complete their cycle. The 7-gallon junipers receive 4 more shearings than the 1- and 2-gallon sizes to complete their growing cycle.

A combination of the number of shearings and the large volume of junipers to be sheared inspired us to come up with a faster way of shearing our juniper crop. I gave a paper (1) last year at the Eastern Region IPPS meeting that describes a shearing machine which eliminates 3 of the hand-shearing operations. Using this machine for an 8-hour day, 2 men can shear about 70,000 1-gallon plants that are can to can and about 40,000 1-gallon plants after they have been spread. Certain cultivars do require some hand shearing behind the shear machine. However, it is usually less than ½ man-hour per 1000 plants.

Spacing is another important factor in determining the outcome of growth manipulation of junipers. Without the proper space the juniper cultivars will rapidly lose their lower foliage, grow in an unnatural manner and completely lose their quality. Our 1- and 2-gallon junipers are grown can to can the first years. *After this period, they are spaced across growing blocks 100 feet* wide in beds 78 inches wide with 18 inch aisles. The 1-gallon containers are placed on an 8 space, which amounts to a 10.2 inch center to center. The 2-gallon containers are placed on a 6 space, which is 14.1 inch center to center. Our 5-gallon plants are on 22 inch centers. Seven gallon plants are spaced according to requirements.

The overwintering of junipers in Oklahoma requires us to bunch the salable crop close together for mutual protection. The one-year-old crop is grown can to can for the first year, so nothing has to be done until spring, which is not true of other

plants. The plants are then spread to allow room for the second growing season.

Timing is going to play a large part in the overall growth manipulation of junipers to obtain quality in the container stock. It is the big key to larger profits If what has to be done in the production of container grown junipers is not timed properly, you can be assured that quality and profits will be reduced.

I have discussed with you 10 points to consider in the overall growth manipulation of junipers. You need to neglect or disregard only one of these and the result will most likely be a second or poor quality plant.

Start with a strong, vigorous liner. Use an adequate container filled with a medium in which you can control the moisture and nutrient levels. Closely monitor the water and fertility needs of the plants. Provide control of insects, diseases, and weeds. Shear for proper growth, space for proper size, and overwinter to protect your investment. Above all, properly time each step in the growth manipulation of junipers so you can be assured that quality and profits will be increased.

LITERATURE CITED

1 Fletcher, J B 1979 Greenleaf nursery's shear machine *Proc Int Pl Prop Soc* 29 290-291

CHARLIE PARKERSON: Questions for Blake Fletcher. How do you shear by hand?

BLAKE FLETCHER: We use Corona grass shears and grab-shear. That is, one hand is placed at the correct height and the plant given a single cut. All the branches are an even height.

CHARLIE PARKERSON: Do you pay on a piecework basis?

BLAKE FLETCHER: No, as we feel it is too difficult to control quality.

CHARLIE PARKERSON: Can you produce a 2-gallon plant in the same time as a 1-gallon?

BLAKE FLETCHER: Yes. The only difference is the cost of 2 liners instead of 1

ATRINAL AND OFF-SHOOT-O IN AZALEA PRODUCTION

RICHARD A. SCHNALL

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The production of azaleas requires that the apical growing points of the plants be periodically removed during the growing

plants. The plants are then spread to allow room for the second growing season.

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The production of azaleas requires that the apical growing points of the plants be periodically removed during the growing

season. This removal induces side branching and produces a well-branched, higher quality plant.

Manual removal is a labor-consuming and costly process. The use of shears to speed up the process often results in neglecting to pinch apical tips occurring below the shearing level. These shoots then grow, and the result is a poorly shaped plant.

Various chemical pinching agents have been developed to replace manual methods This paper compares two of these chemicals.

Off-Shoot-O Off-Shoot-O (2) (methyl ester of fatty acids, Proctor & Gamble) was the first commercial pinching agent for azaleas. It was originally used in tobacco production. When the chemical is sprayed on azaleas, it selectively destroys unexpanded leaves and shoot tips. Branching occurs since lower buds then develop. There must be physical contact between the chemical spray and the shoot tips because the chemical is not translocated.

While many growers have success with Off-Shoot-O, acceptance has been hindered due to problems of stem girdling and crop destruction. Variations in cultural conditions, spray equipment, surfactant, chemical concentration, variety of plant, and maturity of shoot tips have caused erratic and, often, unsatisfactory results (3).

The price of Off-Shoot-O is $65.00 per gal. When applied at a recommended rate of 14 ounces per gal, it costs $7.11 to prepare a gallon of spray. One gallon treats between 100 and 400 square ft of plants.

Atrinal Atrinal (1) (dikegulac, Hoffman-LaRoche) is a plant growth regulator with systemic activity for chemical pinching of ornamental plant materials. When the chemical is sprayed on azalea foliage, it is absorbed and translocated to the plant's apical tips. The chemical temporarily halts apical dominance thereby inducing side branching There is no destruction of plant parts. After treatment, plants temporarily become chlorotic and cease growth. This is followed by a significant increase in the development of new shoots In tests (5), Atrinal has produced more new breaks per shoot than Off-Shoot-O.

While there have been no reports of crop destruction associated with Atrinal, increased production time, due to excessively long delays in growth following treatment, has been experienced by some growers. As yet there is no explanation. In the north the new growth may not have time to harden-off before winter. In addition, a wide range in cultivar response has been noted (3).

However, Atrinal has been demonstrated to have a role in azalea propagation (3,4). Our tests have indicated that Atrinal-

treated stock plants yield cuttings that root normally. These cuttings develop into higher quality liners with more new shoots than cuttings removed from untreated stock plants. In addition, azalea stock plants treated with Atrinal develop more new shoots than untreated stock plants. As a result, more shoots are available for propagation. This can also be an aid in the rapid development of azalea stock blocks.

The price of Atrinal is $89 per liter. When applied at a recommended rate of 1¼ ounces per gal, it costs $3.34 to prepare a gallon of spray.

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AUXINS OTHER THAN INDOLEBUTYRIC ACID WHICH CAN EFFECTIVELY BE USED TO STIMULATE ROOTING

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The chemical identification and elucidation in 1934-35 of the role of auxin [indoleacetic acid (IAA)] in promoting adventitious root initiation was a landmark in the history of plant propagation (8,9). This advancement led to auxin treatment of cuttings to stimulate rooting and made it possible to consistently root large quantities of cuttings from difficult-to-root plants.

Following the discovery that IAA promoted adventitious root initiation, the search began for other naturally-occurring auxins. Also, chemicals with structures similar and dissimilar to IAA

[1] Associate Professor The use of trademarks in this publication does not imply endorsement by the North Carolina Agriculture Research Service of products named, nor criticism of similar ones not mentioned

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were examined for root-promoting properties. The former studies, conducted for many years, were unsuccessful. Currently, it is generally agreed that IAA is the only naturally-occurring auxin found in plants. The latter studies were more successful and, in 1935, appeared the first report indicating the synthetic auxins, indolebutyric acid (IBA) and naphthaleneacetic acid (NAA), had strong root-promoting properties (14). Reports of additional synthetic compounds also classified as auxins and having root-promoting activity appeared in 1942 (5,13). These compounds included 2,4-dichlorophenoxyacetic acid (2,4-D) which, in later years, would be extensively utilized as a herbicide.

Since 1942 additional compounds, both naturally-occurring and synthetic, have been reported to stimulate root initiation in cuttings. However, commercial use has been limited to the auxins IAA, IBA, NAA, and to a limited extent, several of the phenoxy compounds When used to treat cuttings, these materials have been utilized alone or in combination. Sometimes when used in combination they are more effective than when used alone (4).

An interesting sidelight to the discovery of the role of auxin in root initiation occurred in 1933. At that time reports appeared demonstrating that certain gases such as acetylene, carbon monoxide, ethylene and propylene could promote rooting in cuttings of various plants (11,12). In herbaceous cuttings the response consisted of stimulation of root initiation and/or root development. For woody cuttings the response was merely development of existing root primordia (12). Little of this information has ever been used commercially by propagators. The role of ethylene in regulating certain plant physiological processes has received much attention in recent years. This is due to the natural production of ethylene by plants and its effects on such processes as fruit-ripening and abscission of leaves and fruit.

With the knowledge that cuttings could be treated with auxins to promote rooting, techniques were developed for treating cuttings with root-promoting compounds (3). These techniques included the application of auxin-talcum powder mixtures, the concentrated-solution-dip method (quick-dip method) and the dilute solution soaking method.

Initially, propagators prepared rooting formulations from reagent grade chemicals. Soon, a number of companies offered for sale, various commercial rooting formulations, under a variety of trade names. These commercial formulations consisted of two general types: one in which a particular concentration of auxin or several auxins were dispersed in talcum powder and a second in which one or more auxins were dissolved in a solvent. The solutions were usually concentrated and had to be diluted by the user before treatment of cuttings.

Of the two commercial rooting formulations the auxin-talcum powder mixtures have remained popular as evidenced by wide use and the numerous trade names under which these formulations are sold. Despite availability of commercial formulations, many propagators preferred to purchase the reagent grade of a particular auxin or auxins and prepare their own rooting formulations. This had the advantage of being more economical than purchasing commercial products It also allowed propagators greater flexibility in terms of the concentrations of formulations they could prepare. For those individuals who chose to prepare their own rooting formulations, the auxin most often purchased was reagent grade IBA. For a number of reasons IBA was the auxin of choice, one of which was its effectiveness in comparison to IAA and NAA (3,14). Through the years IBA could be purchased from several chemical supply houses in the United States. However, action taken by the United States Environmental Protection Agency (EPA) in early 1978 has alarmed propagators who purchase and utilize reagent grade IBA.

STATUS OF THE AVAILABILITY OF IBA IN THE UNITED STATES

Although clarification on this point has been difficult, it "appears" with the exception of propagators in California and scientists throughout the country that the purchase of reagent grade IBA by propagators from producers has been halted by the EPA (1). This has resulted since an EPA registration number has never been granted for its use. Until recently, federal registration of reagent grade IBA had never been sought. Reagent grade IBA can be sold by producers to commercial formulators who hold valid EPA registration numbers on the IBA-containing rooting preparations which they formulate and offer for sale This explains why IBA-containing rooting preparations are still readily available.

Several trade organizations and chemical companies are in the process of acquiring national registration of technical grade IBA (1). Thus far, no valid registration has been granted. Meanwhile, propagators who use IBA are concerned because their remaining supplies are dwindling or exhausted and they cannot reorder. Hopefully, the halt on the sale of reagent grade IBA to propagators will be rescinded. However, before this happens, what alternatives, if any, does a propagator have? Are there any other compounds which an individual might use to stimulate rooting with results comparable to IBA? Let us consider some alternatives.

ALTERNATIVES TO BE USED IN PLACE OF IBA

In the past, if a propagator purchased reagent grade IBA,

the individual was undoubtedly preparing rooting formulations of desired concentrations. With reagent grade IBA now unavailable, a propagator has one of two choices; either purchase commercial rooting formulations or find a suitable substitute for IBA. Numerous possibilities exist for the first choice, and further explanation is unnecessary. Finding substitutes is not as obvious.

Any substitute for IBA should be an auxin. Although plant hormones other than auxins and chemical compounds not classified as growth regulators have been reported to stimulate adventitious root initiation in cuttings, auxins are generally the most effective compounds for achieving this goal. If one considers the reasons for treating cuttings with root-promoting compounds the auxins will out-perform all other materials (2). Before considering other auxins it should be kept in mind that a stimulatory response to auxin is not always possible. When treated with auxin, cuttings of many species show a stimulatory response while cuttings of other species do not. In summary, a stimulatory response to auxin is not universal.

Indoleacetic Acid (IAA). As an alternative to IBA one could consider IAA, the only naturally-occurring auxin. Use of IAA has not been widespread commercially because it is not as effective as IBA or NAA in promoting rooting (3,14). A possible explanation for the reduced root-promoting activity of IAA when applied to cuttings is that plant tissues possess several metabolic mechanisms which function for removal of IAA from the growth regulating system (6). In simple terms, plants possess mechanisms which operate to reduce and/or eliminate the effectiveness of IAA. There are also other problems associated with the use of IAA. Unsterilized solutions of IAA are rapidly destroyed by microorganisms (2) Similarly, strong sunlight also destroys IAA solutions (2,7)

IAA could be used as a substitute for IBA but there are problems associated with its use; one being that it is not as effective as IBA There are better choices.

Naphthaleneacetic Acid (NAA). NAA appears to be the best alternative to IBA This auxin has been shown to promote rooting in cuttings from a wide range of species. Effectiveness is further illustrated by its use in Rootone and the use of some closely related compounds, including naphthaleneacetamide, in several well-known commercial auxin-talcum powder formulations.

Though effective in stimulating rooting, reagent grade NAA has never been used extensively by propagators, probably due to an early report indicating it was not as effective as IBA in promoting rooting (3). This same report showed NAA was more effective than IAA.

In comparison to IBA, NAA is more toxic over a wide range

of concentrations. Often the NAA concentration which promotes optimum rooting is close to a toxic concentration which leaves little margin for error. If a propagator decides to use NAA, studies should be conducted to determine optimum rooting concentrations. Despite the somewhat narrow concentration ranges over which this material may be used there are other factors which favor its use in comparison to some of the other auxins such as IAA. NAA is more resistant to microbial destruction than IAA and is light-stable (2). NAA would be a suitable alternative to IBA in addition to being more economical than IBA.

Phenoxy Compounds. A third alternative to IBA might be the phenoxy compounds such as 2,4-D, 2,4,5-trichlorophenoxyacetic acid (2,4,5-TP). These compounds, classified as auxins and used primarily as herbicides, promote rooting in cuttings from many species when used at extremely low concentrations. Though relatively light-stable and resistant to microbial decomposition they have not been used extensively for propagation (2). There are several reasons for this, one being that following rooting these materials inhibit shoot formation (2). Inhibition of shoot formation has been attributed to translocation of these compounds to the buds (10)

Phenoxy compounds when used to treat cuttings often stimulate callus-like growth on the bases of cuttings. This growth is usually associated with numerous short roots which appear bent, thick and stub-like in appearance. It is not unusual to observe masses of these short roots in which the individual roots are fused together. This type of root system is in direct contrast to strong fibrous root systems produced by IBA. Roots produced by the phenoxy compounds often develop slowly which, in turn, affects overall growth of the cuttings. Another problem is that the concentration which promotes rooting often causes necrosis of hte portion of basal stem treated. If the concentration used is greater than the optimum rooting concentration, severe injury or death of the cuttings may result. Thus, this illustrates the very narrow range of concentrations in which these compounds may be safely used.

A possible procedure of utilizing the phenoxy compounds might be to use a small quantity in combination with another auxin such as NAA. One report indicated that when this technique was used, greater stimulation of rooting was observed in comparison to using a phenoxy compound alone (5)

CONCLUSIONS

Until reagent grade IBA again becomes available to propagators, alternatives must be considered. For propagators who desire to prepare their own rooting formulations the best alterna-

tive appears to be some of the other auxins, particularly NAA. This auxin is readily available from several chemical supply houses in the United States and is cheaper than IBA. Other possibilities include IAA and the phenoxy compounds although problems are associated with their use.

Alternatives should be considered carefully. This includes conducting empirical trials to determine optimum rooting concentrations. Such trials will be necessary because reports in the literature concerning optimum auxin concentrations for stimulating rooting deal primarily with IBA.

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CURRENT STATUS OF DOGWOOD CANKER

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Abstract A stem and trunk canker of undetermined cause has been damaging flowering dogwood for the past 13 years in Virginia Fungicides applied to the leaves and stems were ineffective in preventing cankers Pruned trees had fewer cankers per tree and there were fewer cankered trees among them

We have observed cankers of undetermined cause on the stems and trunks of white flowering dogwood *(Cornus florida)* in nurseries in Virginia for the past 13 years (2). During this time we have been unable to isolate the fungus *Nectria galligena* (4), the cause of perennial target canker, or the fungus *Phytophthora cactorum* (1), the cause of crown cankers, from any cankered trees. In some cases two-year-old seedlings planted in our experimental field developed cankers by the end of the first growing season following transplanting to the field. We have noticed that canker development varied among different lots of trees. For example, there was no canker development after five years in one lot of 25 trees from an out-of-state source when they were planted at Virginia Polytechnic Institute and State University (VPI & SU) in Blacksburg.

Symptoms of disease. Cankers are of two different forms, appearing either as a sunken canker, or as a severe roughening of the bark at localized areas above the ground. The sunken canker frequently causes early girdling and death of the top with sprouting of shoots below the canker. The cankered trees break easily in the wind. Rough bark cankers on the trunk become slightly swollen and pronounced. Cankers are commonly invaded by insects, which can be very damaging. A small number of trees that were previously free of trunk cankers have developed cankers in the upper limbs (Figure 1).

Observations on canker incidence and control. Several different fungi including species of *Alternaria* and non-sporulating fungi have been cultured consistently from the margin of newly-formed cankers; but when inoculated into healthy seedlings, none of these have been observed to produce cankers.

When three groups of 25 two-year-old seedlings from three different nurseries in three different states were planted in the same research plot near VIP & SU and grown under the same conditions, incidence of canker after the first growing season was 0% in one group and over 50% in another group.

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[1] Associate Professor and Professor, respectively

Fungicide treatments. Two-year-old seedlings were immersed so that the entire plants were soaked for 30 minutes in solutions of different concentrations of potassium azide and benomyl (Benlate®) and planted in the field. The trees soaked in a solution of 1000 ppm of benomyl had 75% cankers at the end of the first growing season compared to 41% cankered trees in the control. None of the low or intermediate concentrations of potassium azide were effective in reducing canker and the highest concentration (4000 ppm) was toxic to the trees (Table 1).

Table 1. Chemical soaks for canker control[1]

Rate, ppm	Percent surviving	Percent cankered	
	10-29	6-20	10-29
Nontreated	100	33	41
500 ppm KN_3	100	9	50
1000 ppm KN_3	100	0	50
1000 ppm Benomyl	100	16	75
2000 ppm KN_3	100	16	42
4000 ppm KN_3	0	16	0

[1] Plants 24-30" in height treated April 23, 1974, 12 plants/treatment

Spring and summer applications of several different registered fungicides at recommended rates repeated bi-weekly to both the developing foliage and trunks failed to prevent canker development (Table 2). In the same treatment, some trees were killed and others were free of cankers.

Table 2. Fungicide sprays for protection against canker[1]

Treatment	rate/100 gallons	Foliage[2] rating	Canker development[3]	Growth index (cm)[4]
Daconil 2787 F	1 5 pt	2 7	3 1	41 7
MF-586 75W	1½ lb	2 2	2 3	39 7
Benlate 50W	1 lb	3 0	3 0	37 2
Daconil 2787 75W	1½ lb	3 1	3 0	34 8
Phaltan 75W	1½ lb	2 0	2 8	38 2
Control	—	3 1	3 0	37 0

[1] The adjuvant Exhalt 800 was added to all treatments except Daconil, at the rate of one pint/100 gallons Eight trees/treatment

[2] 1 = a healthy tree, 2 = off color, 3 = wilt and yellow leaves, 4 = premature reddening and leaves smaller than normal, 5 = top of tree dead

[3] 1 = healthy trunk, 2 = a single canker, 3 = 2 to 3 cankers, 4 = 4 or more cankers, 5 = top of tree dead above canker

[4] Growth index = height above soil line added to canopy at greatest diameter divided by two

Observations on the effect of pruning on canker development. We have reported that there was no evidence that pruning had any effect on the incidence of canker on white seedling dogwood after two growing seasons in the field (3). However,

after a third growing season there were among the pruned trees fewer cankered trees and fewer cankers per tree (Table 3). Similar experiments are being conducted in other states adjacent to Virginia.

Figure 1. Stem canker of dogwood. *Left.* Sprouting below a canker that has girdled the top of the tree. *Center.* Rough bark canker on the main trunk. *Right.* Cankers on the upper limbs of a previously healthy tree.

Table 3. The effect of pruning on canker development on white dogwood seedlings[1].

	1979		1980	
	Pruned	Unpruned	Pruned	Unpruned
No. of cankered trees	29	30	24	32
No. of cankers per tree	1.01	1.06	1.17	2.00
No. of surviving trees	45	44	39	40
No. of healthy trees	16	14	15	8
Percent cankered trees	58	60	61	80

[1] One hundred 2-year-old seedlings planted March 1978. One-half of the trees were pruned and the other half left unpruned.

DISCUSSION

Nurserymen in Virginia have experienced a considerable loss of salable dogwood trees due to canker infection. The source of trees appears to be important. At planting, all of the trees in our research have been visibly free of canker, but a large number have become cankered after only one growing season. If the cankers are of the sunken type, the trees will probably die above the canker and frequently break off. The below-canker portion of the trunk and the roots may remain alive and continue to produce shoots. We have observed that some of the shoots will become cankered. On the other hand, trees that were apparently

free of canker for several years (as determined by close visual examination of the main trunk) have recently developed cankers in the upper branches. This late cankering has occurred on trees growing in close proximity to trees that are cankered but have survived for 5 years.

Fungicides ordinarily applied for leaf spot disease protection have been ineffectual against dogwood canker. This would suggest a systemic pathogen that is untouched by fungicides applied to outer plant surfaces, if the pathogen is indeed a fungus Dogwood trees are usually pruned to develop a single trunk and pruning wounds may serve as entry points for pathogens. However, unpruned trees in our plots had more cankers than pruned ones. No common fungal pathogen has been isolated from cankers. All attempts at causing cankers with fungi isolated from cankers has been unfruitful. Other pathogenic organisms should be considered as possible causal agents.

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RHODODENDRON PRODUCTION

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Rhododendron production in the U.S. was for many years centered in the Pacific Northwest, particularly in the Oregon and Washington area. It has gradually moved east and is progressing further south. We feel that the significant differences in our production are that we are growing finished plants in full sun at lower elevation and further south than has previously been reported on a commercial scale Otherwise our techniques are traditional.

Rhododendron production at Kinsey Gardens accounts for about one-third of our nursery sales. Our other major crops are azaleas and conifers. We are presently growing about 25 large-leaved rhododendron cultivars and several dwarf or small-leaved ones. Most of these are of H-1 or H-2 hardiness. The majority of

free of canker for several years (as determined by close visual examination of the main trunk) have recently developed cankers in the upper branches. This late cankering has occurred on trees growing in close proximity to trees that are cankered but have survived for 5 years.

Fungicides ordinarily applied for leaf spot disease protection have been ineffectual against dogwood canker. This would suggest a systemic pathogen that is untouched by fungicides applied to outer plant surfaces, if the pathogen is indeed a fungus Dogwood trees are usually pruned to develop a single trunk and pruning wounds may serve as entry points for pathogens. However, unpruned trees in our plots had more cankers than pruned ones. No common fungal pathogen has been isolated from cankers. All attempts at causing cankers with fungi isolated from cankers has been unfruitful. Other pathogenic organisms should be considered as possible causal agents.

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RHODODENDRON PRODUCTION

JOHN ED. KINSEY

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Rhododendron production in the U.S. was for many years centered in the Pacific Northwest, particularly in the Oregon and Washington area. It has gradually moved east and is progressing further south. We feel that the significant differences in our production are that we are growing finished plants in full sun at lower elevation and further south than has previously been reported on a commercial scale Otherwise our techniques are traditional.

Rhododendron production at Kinsey Gardens accounts for about one-third of our nursery sales. Our other major crops are azaleas and conifers. We are presently growing about 25 large-leaved rhododendron cultivars and several dwarf or small-leaved ones. Most of these are of H-1 or H-2 hardiness. The majority of

the plants are marketed in 2- and 3-gallon containers; and some are sold in half-bushel baskets. We strive for a one to two year turnover Knoxville, Tennessee, is in hardiness zone 7 and is about 800 feet in elevation. We feel that we are in a good rhododendron production climate We get three full flushes of growth per season, a good percentage of flower buds on many cultivars the second season, and have relatively few disease problems.

Our production begins with propagation of cuttings taken from vigorous one-year-old plants in 1 and 2 gallon containers. Cuttings of the last flush of growth are taken in November after fall sales slow down and after the poly houses are covered. In fact, we could successfully root cuttings year round if it would fit our production schedule. Cuttings are put in plastic bags and taken to the greenhouse where they are prepared. We first wash the cuttings in a Benlate (benomyl, duPont) and Captan solution for about 5 minutes. Then they are drained and rinsed with clean water so they can be handled and prepared All leaves are removed from the base leaving 3 to 4 leaves near the apex. The apical bud is pinched out and the stem is wounded on both sides through the cambium with a sharp knife. A fresh cut is made at the base of the cutting to trim to uniform length and to remove the water-soaked base of the cutting. Care is taken to keep the cuttings clean after the fungicide soak. We do not trim the leaves to a shortened length except on a few cultivars with excessively long foliage. Cuttings are then treated with 0.8% IBA (indole-3-butyric acid) in talc and stuck into a 6-inch-deep raised bench containing a 2:3 mixture of sphagnum peat and coarse perlite. The houses and benches are thoroughly cleaned, painted with cuprinol, and the mix changed after each crop. Bottom heat is supplied by a propane-fired unit heater attached to a convection tube, which is routed under the bench Heat is forced up through the medium by sealing the sides of the bench to the ground with a poly skirt. We try to maintain 72° to 75°F soil temperature as we feel this is important for winter propagation. Mist is controlled by a time clock with manual corrections for weather changes. When the bench is completely filled, cuttings are usually then drenched with Truban (ethazol, Mallinckrodt) and Benlate.

After 2 to 3 months the cuttings are tight and are lifted in February and potted into quart containers. These are put into a heated house and forced into immediate growth Photoperiodic lighting is begun on these potted plants in early spring to simulate long days. We often get 1 to 2 flushes of growth before May when we can take them outside and shift into 2-gallon containers While in the small pot we liquid-feed and pinch very conscientiously to develop a well-branched body.

The plants are moved outside and shifted into 2-gallon containers. The potting mix is 4:1 pine bark and expanded shale containing 8 pounds of Sta-Green Pro-Start, a potting soil fertilizer containing gypsum, superphosphate, urea formaldehyde, potassium nitrate, and micronutrients; 10 lbs. of dolomitic lime; and 10 lbs. of Osmocote 18-5-11 12-month fertilizer per cubic yard. Little additional fertilizer is necessary the first year. The rhododendrons are grown in full sun the year round except possibly for a short acclimation period after moving the quart pots from the poly houses. We feel that the full sun makes the plants stockier, cleaner, deeper-rooted, better budded, and generally tougher for use in the landscape. During the summer the plants are irrigated only in the morning every other day. Water is supplied overhead by Nelson Whiz Heads. Even if the plants flag during the heat of the day, we do not water as long as the medium is still wet. We feel that overwatering is one of the biggest hazards in rhododendron production. The plants in the 2-gallon cans remain can-to-can in the uncovered poly houses the first summer. Weed control in the cans is accomplished with Ronstar (oxadiazon, Rhone-Poulenc). The rhododendron growing area is on a slight slope and is graveled with ¾ inch crushed stone to insure proper drainage and to help prevent root disease problems. Irrigation water comes from ponds fed by surface and spring water. During the first year the plants are pushed hard and carefully pinched at each flush. During the hot, humid periods the leaves and stems are protected by bimonthly sprays with such materials as Dithane M-45 (mancozeb, Rohm & Haas), Daconil (chlorothalonil, Diamond-Shamrock), Benlate (benomyl, duPont), Orthene (acaphate, Chevron), diazinon, Sevin (carbaryl), and Kelthane (dicofol). We use a John Bean hydraulic sprayer as we are too close to a residential area to allow use of a mist blower-type sprayer. We do little or no drenching of the medium after the plants leave the quart pots. We depend on proper potting medium and watering practices to control root diseases.

All plants are overwintered under clear poly in 15-feet-wide polyhouses. Some cultivars of the vigorous 1-year plants often have to be protected from early frosts by irrigation or by covering early. We must protect this last flush of growth for it is the source of our winter cuttings. Generally, we like to have all houses covered by Thanksgiving The doors of the rhododendron houses are left open except during very severe cold periods. We had first hoped to grow outside during the winter, but 1977 convinced us this was too risky. Cuttings are taken from these 1-year plants, which again prunes and induces branching in the following spring flush. Some of these plants are sold at this stage as unbudded 2-gallon plants with picture tags.

Then the following spring, the more vigorous cultivars are

shifted to 3-gallon containers for finishing. The less vigorous cultivars, or smaller graded plants, are spread out and left in the 2-gallon can to produce a heavy, 2-gallon, often budded, plant by the second fall. We are able to produce an 18- to 24-inch plant in 2 years by following this schedule.

Cultivars that we like to grow and which do particularly well under our conditions include 'Roseum Elegans', 'Roseum Superbum', 'English Roseum', 'Catawbianse Boursault', 'America', 'Nova Zembla', 'Anah Kruschke', 'P.J.M.', 'Blue Ensign', 'Chinoides', 'Gomer Waterer', 'Catawbiense Album', and 'Anna Rose Whitney'. Some cultivars such as 'Scintillation' tend to leaf scorch when grown in full sun and should possibly be shaded for best results in our area.

RHODODENDRON PROPAGATION

TED GOREAU

Imperial Nurseries
Quincy, Florida 32351

Imperial Nurseries' southern division is located in Quincy, Florida, approximately 20 miles northwest of Tallahassee. The climate in this part of north Florida is mild compared to the endless summers farther south or the long winters of the northern states. The long growing season, abundance of good water, and moderate winter temperatures of this area combine to make it virtually ideal for growing many species of ornamental shrubs and trees in containers.

Although most of the woody ornamentals grown here require little or no cold protection, some species do require special handling because of the prolonged periods of high humidity and warm temperatures that are common in the summer months. There are several cultivars of rhododendron among this group.

At the southern division of Imperial Nurseries the cultivars of rhododendron receiving special handling are *Rhododendron* 'Nova Zembla', *R.* 'Roseum Elegans', *R.* 'English Roseum', *R.* 'Pink Treasurer' and three catawbiense cultivars — 'Catawbiense Grandiflora', 'Catawbiense Boursalt', and 'Catawbiense Album'. These plants are more susceptible to water mold and other fungus-related diseases and are more sensitive to heat stress than most species we grow, making proper irrigation, drainage, and frequent fungicide applications critical. They require slightly lower fertilizer levels, hand pinching and, because they are more prone to mechanical damage, shipping in cartons, as opposed to the solid stacking method we normally use. One, two, and three

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gallon containers are shipped by stacking one can on top of another with each can resting on the upper lips of the two cans beneath it. All of the rhododendrons we produce are grown in 5-inch pots and are the smallest container we sell. After they are potted, the plants are closely spaced in beds and remain there until they are shipped. Concentrating the plants in a relatively small area allows us to make more efficient use of the labor required for such procedures as hand pinching, dry fertilizing, weeding, and shipping. It also reduces the cost of pesticide applications and liquid feeding.

Experience has shown that environmental factors such as temperatures, light intensity, and moisture content of the propagation and growing media more acutely affect the speed and quality of root formation on rhododendron than on other species in production here. Heavy wounding and higher-than-normal concentrations of rooting hormone have also proved advantageous. This is particularly true when working with the slower rooting cultivars.

PROPAGATION

We have traditionally begun rhododendron propagation in mid-to-late October when the latest break had completely hardened off and the plants were in a semi-dormant state. The cuttings were stuck in heated greenhouses on open benches equipped with mist lines and bottom heat cables. Most plants were rooted by the end of December when misting was discontinued and soil and air temperatures were reduced. At the end of January the cuttings were potted and stored in unheated greenhouses until spring when they were moved to a shaded growing area. All shade at Imperial of Quincy is 30 percent.

Although this procedure worked fairly well, it was labor intensive and the steadily deteriorating benches were increasingly difficult to disinfect and maintain By September, 1978, the condition of the benches had declined, literally, to the point of collapse. Replacement benches were designed and built to house 12 in by 18 in by 4 in flats. Benches are simply a frame constructed of 2×6 boards laid flat and nailed to 2×4 inch crosspieces with the whole resting on cinder blocks. Benches are easy to clean and disinfect and are virtually maintenance-free. Where the old benches had to be laboriously filled with and emptied of media, bucket-brigade fashion, the flats can be filled outside the cramped greenhouses and rolled in on conveyer tracks several at a time. The savings in labor costs are significant.

One distinct disadvantage of using flats instead of open benches is that the flats are not conducive to the use of the electric bottom heat cables salvaged from the old benches. Al-

though we were cognizant of the benefits of bottom heat in rooting cuttings, budgetary limitations, and the lack of time prevented our installing an alternative system such as steam or hot-water pipes. The decision was made to proceed without bottom heat with the proviso that a system be added later if necessary.

The first crop we rooted without basal heat was, for the most part, satisfactory. The cuttings produced roots of a good quality and number and the attrition percentage was acceptable. In fact, the only major difference we observed was that their rooting time was increased by approximately one month over previous years.

Only two of our 45 greenhouses are equipped with thermostatically actuated heaters and fans. Although they are primarily intended for rhododendron propagation, we have also used them for the propagation of certain hard-to-root junipers after the rhododendrons are removed. As cuttings of these particular junipers species root best when taken before mid-February, it was obvious that if we were to continue propagating them in heated greenhouses we must, somehow, compensate for the extended rooting time of the rhododendron. We have apparently accomplished this by moving forward the date on which we commence propagating.

We began cutting rhododendrons this year on September 15. The material was, of course, much softer than we were accustomed to and more than usual effort was required to prevent wilting. All cultivars were showing light roots by the second week in November and we are confident that they will be pottable on or ahead of our traditional schedule.

Aside from moving forward our beginning date, our actual propagation methods are basically unchanged. The cuttings are taken from leaders of the coming year's salable crop in such a manner as to level off the tops of the beds. Unusually vigorous shoots may have two or more joints removed but, in general, only the latest breaks are removed from each plant. Although many propagators shun vigorously-growing leaders in favor of lateral shoots, the small size and the need to maintain the salability of our cutting stock make lateral growth unavailable for cuttings. Leaders, however, do root satisfactorily and, because the plants are bedded, can be harvested more economically than lateral growth

All cutting for each day's production is completed by 10 a.m. The cuttings are placed on a mist-equipped bench inside the propagation shed in chronological order so that the first ones cut will be the first processed and stuck. Before processing begins all shears are disinfected and the cuttings are washed in a solution of Benlate (benomyl, duPont Chemical), 1 tablespoon per gal.

After washing, the cuttings are placed on a transite-surfaced work table. The leaves on each cutting are reduced to a maximum of four and the stem is trimmed at the base to about three inches in length. The base of each cutting then receives a double heavy wound and is dipped in a mixture of IBA (indole-3-butyric acid) and talc. *Rhododendron* 'Nova Zembla' is treated with 2% IBA in talc. All other cultivars are treated with 0.8% IBA in talc. All cultivars receive a double heavy wound. They are then heeled in trays, covered with damp burlap and hauled to the greenhouses as needed for sticking. The cuttings are stuck 1½ in apart to a depth of about 1 in in a medium consisting of 40% Canadian peat, 40% coarse perlite and 20% sharp sand. As each flat is completed, it is flooded with water to insure intimate contact between the medium and the bases of the cuttings.

The cuttings are misted at four minute intervals during the daylight hours. After one week, the mist cycle is reduced to 8 minute intervals when the ventilation fans are running, or 16 minutes or more when the fans are off. The initially high rate of misting is intended to soften the shock of removal from the mother plant. In any case, some moisture is visible on the foliage at all times during the rooting process.

The heaters, though they are infrequently needed, are thermostatically set to maintain a minimum air temperature of 55°F and the ventilation fans come on when air temperature reaches 75°F. On sunny days it is not unusual for the average temperature inside the greenhouses to climb as high as 95°F. However, due to the unobstructed flow of air across the foliage and the resulting advective and evaporative cooling, the air close to the cuttings is always several degrees cooler than the average ambient temperature inside the greenhouses.

Throughout their stay in the greenhouses, the cuttings are treated weekly with Benlate, Manzate 200 (manek, duPont) and Daconil (Diamond Shamrock) applied separately on a rotating basis. The benches are inspected at least once daily and dead or diseases plants are removed as soon as they are observed. Misting is gradually reduced when light rooting begins. When most plants are rooted, misting is discontinued and the minimum air temperature lowered to 35°F. Before potting, several weeks are allowed for the cuttings to become cold acclimatized and make additional root growth.

POTTING AND LINING-OUT

When the plants are judged ready for potting, they are dug well beforehand and heeled-in in trays Any plants with insufficiently developed roots are restuck and unrooted cuttings are discarded. The potting medium consists of approximately equal

parts of Canadian peat, sharp sand, and uncomposted milled pine bark. Fertilizer and pesticides are already incorporated in the pine bark when we receive it from the milling plant.

As was previously mentioned, we traditionally stored newly-potted rhododendrons in unheated greenhouses until spring. Several years ago, however, increases in production and a shortage of greenhouse space prompted us to experiment with overwintering a small portion of our crop without cold protection. The results were encouraging, and now all of our rhododendrons are lined out directly in the growing area as soon as they are potted. After two years we have observed no detrimental effects from this practice. In fact, the unprotected plants seem to break more uniformly in the spring than those we formerly protected. There has been a definite reduction in the man-hours required for hand-pinching of the terminal buds to encourage lateral growth.

GROWING

Our most serious stumbling blocks in achieving successful rhododendron production were root-related and were due largely to the physical characteristics of our growing area and techniques. It was not unusual in the past to find a well-branched plant 14 in high with a root system that filled less than half of a 5-in pot. Water mold infections were common and extremely difficult to check. The plants were packed tightly in wire baskets or metal flats laid directly on plastic film-covered sections that had little or no gradient. Watering was done with portable sprinklers, and the umbrella effect produced by the tightly bedded plants necessitated frequent hand watering. Though awkward, this system was not impossible as long as there was adequate personnel available and production remained on a small scale. With the expansion of production, however, modifications became imperative.

The old shade was replaced and the sections have been regraded with a pronounced crown. Five-inch square pots were acquired and bedded in rows of eight, perpendicularly across the sections and the bottom of each pot was filled with a 2-inch layer of pea gravel to enhance drainage. The plants, which are potted in 5-inch round cans, are merely dropped into available openings (empty 5-inch square pots) until each bed is filled. They need not be moved again until shipped. This technique effectively anchors the plants and provides enough spacing to allow the flow of air, pesticides, and water to the soil. It has the added advantage of simplifying inventorying and handling. We also installed a permanent irrigation system that employs Rain Bird model #30-A double-headed sprinklers. Fittings are provided that allow injection pumping of fungicides and fertilizer directly into the main

lines. We are trying to isolate the rhododendron irrigation from the rest of the nursery so as to increase the flexibility of our water applications.

Since these modifications were effected, there has been a marked improvement in the quality of the root systems on our rhododendrons and a general decline in the incidence of fungus infections.

SUMMARY

Miraculous innovations and magical cures are rare in any horticultural endeavor. We feel that the success we have, so far, realized in the production of rhododendrons is due to the development of sound propagation and growing techniques and their meticulous application. Although there are many crucial factors, we feel that those most pertinent to our situation are sanitation, disease prevention, efficient irrigation, and drainage.

In the propagation phase, all tools used for harvesting and processing of the cutting are washed in LF-10 (an organic disinfectant manufactured by Sterling Drug, Inc.) at least once daily. At the end of each work week the entire propagation facility including trays, cutting storage bench, work table, and floors are also sanitized The schedule of fungicide applications to the cuttings previously mentioned is rigidly adhered to as is the removal of dead and diseased plants from the propagation benches As much time as is practical is spent metering the misting cycle to maintain the turgidity of the cuttings and yet avoid over-saturation of the propagation medium.

In the growing phase, all pots that are not new are fumigated with methyl bromide and a continuous effort is made to obtain only uncontaminated components for the potting medium. Immediately after potting the plants are drenched with the fungicides Benlate and Truban (ethazol, Mallinckrodt) at the rate of 5 fluid ounces of Truban and 8 ounches by weight of Benlate per thousand square feet. Drenching is repeated every eight weeks as a preventive measure, or more often as a symptomatic treatment. During the warmer months, the plants are sprayed bi-weekly with the insecticides Diazinon (Ciba-Geigy) and Orthene (acephate, Chevron) applied in rotation and in combination with the same fungicides used in the propagation phase. As in all phases of production dead or diseased plants are removed and destroyed as soon as they are observed.

QUEENSLAND NATIVE PLANTS SUITABLE FOR CULTIVATION

NOEL CHOPPING

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Queensland is a vast state of some 667,000 square miles. It has 3,263 miles of coast line and is situated in the tropical and sub-tropical southern zone, with the Tropic of Capricorn passing through Rockhampton. The state is divided by a series of mountain ranges and spurs along the east coast which form The Great Dividing Range. This mountain range varies from a few miles off the coast to 200 miles inland. It is the coastal side of this range that receives the bulk of summer rains. The areas where the range is close to the coast are predominantly rain-forest areas, marshy low-land Melaleuca or coastal Wallum areas. Summer monthly rainfall in this area varies from 200mm to over 500mm in the northern tropical regions. The rain-forest contains a wealth of trees and shrubs suitable for cultivation as garden and indoor plants Unfortunately many have still to be collected and tested, but time is running out as great areas of our rain-forests are being cleared at an alarming rate for commercial crops. The areas around Townsville, Rockhampton, Gladstone, and Gympie are classified as semi-arid with annual falls of tropical flood rains. West of the Great Dividing Range is mostly semi-arid to arid with annual rainfall of 100 to 500 mm. It is from these drier western areas that the bulk of our most colourful and most desirable garden annuals, low growing shrubs, and small trees come. Unfortunately the majority of these are not successful in garden cultivation in coastal areas. Of the countless number of species from inland regions tried by members of the Society for Growing Australian Plants, Queensland Region, only a small minority of species of *Callistemon, Grevillea* and *Acacia* could be classified as suitable for general garden use in the populated east coast cities and towns where at least 60 percent of the state's population reside. Also, over 70 percent of the state's nursery industry is contained along this coastal strip with the majority of commercial production found within a 100 mile radius of the state's capital, Brisbane, which is situated in the southeast corner of the state.

COLLECTION OF SEED AND FRUITS

When travelling the vast areas of Queensland, without doubt the easiest and most efficient method to collect plant material is by seed. This can be picked and later, at leisure, propagated. My method of collecting seed is to remove as much plant material as possible from around the seed capsules and place them in either

a wet-strength paper bag or a cloth bag. If the plant is known, record its botanical name, location of collection, and date on the bag. An unknown plant is given a code number and a pressing is made for herbarium identification. On returning home the seed is air-dried and cleaned. Fleshy fruits, which are collected from either palms or rain-forest trees, are stored with flesh intact in plastic bags and marked as previously stated, making sure they are stored in a cool, shaded spot in the car while travelling. Where possible, I clean the pulp from the fruits before sowing. Most of this seed has a very short viability, usually one to six weeks, and it is essential to keep it in a moist atmosphere. Most of this type of seed will keep and still germinate after three to six months if treated as follows: Clean the pulp from the seed in running water and remove the excess moisture with paper towelling, place the seed in a clean plastic bag, then roll up the bag squeezing out as much air as possible, tie with a rubber band and place on the lowest shelf of a moist, cold refrigerator. Some of this seed will even show signs of germination on removing from storage. I have on many occasions used a plastic bag to pre-germinate rain-forest tree seed of *Harpulia, Eugenia, Randia,* etc. *After towelling, place the seeds in the plastic bag, blow the bag* up like a balloon and tie. Place in a warm, well shaded, spot and germination occurs in 5-7 days. Leave for about three weeks and you almost need an axe to separate the seed lines. I then sow the pre-germinated seed into individual 2-inch tubes. This method can save up to four weeks in tube production. Hard woody seed capsules like those of *Banksia* and *Hakea* usually require some type of heat application to make them release their seeds. Much can be learned from nature and people living in bushfire-prone areas can vouch for the ferocity of the fire that passes through the *Banksia* and *Wakea*-studded bushland. Although this fire is fierce, it is also relatively short. Many methods have been used to extract these seeds. I find the best results are obtained by fiercely burning the seed cones with a large porta-gas blow torch or, better still, an oxy-acetylene torch. Leave the burnt cones for a few days and then by tapping them, most of the seeds should fall out. With *Banksia* and *Hakea,* as well as all other winged seeds of the same size and larger, I sow point down with the base of the wing just level with the soil surface. For most of our seed propagation we use a mix of German peat moss, perlite, and coarse sand in equal proportions. To this we add 6 lbs of garden lime to the cubic yard. No fertiliser is added; this is applied in liquid form after germination.

COLLECTION OF GREEN PLANT MATERIAL

Collection of cutting material in the wild presents problems that seem to magnify out of all proportions as the distance and

length of travel from home base increases. Also most material collected from natural habitat will generally be of poor quality and success rate at best will most probably only supply enough propagated material to get the species started in cultivation. This, in my opinion, is all that any propagator should require of the bushland. Although there are exceptions to this with material coming from wetland and rainforest areas, I think the same principle of removing only enough material to establish stock plants should be taken. Many a time when an unusual or rare form of species is discovered and the knowledge broadcast it is wiped out by over-collecting. When I collect cuttings from the wild I take only tip cuttings and if the material is on the hard side I take only a few hardwood cuttings to set. On 1 to 3 day trips I usually use plastic freezer bags to store cuttings. These, on returning to vehicle or campsite are lightly sprayed with water and the bags partially blown up, tied, placed in a polystyrene box and stored in a cool, shaded spot. On longer trips cuttings become a greater problem. Space in vehicles is at a premium and polystyrene boxes require a lot of room but are still ideal for storing a large number of cuttings. The two methods I have used are:

(1) Prepare the cuttings roughly to size and pack between layers of damp newspaper, one layer on top of the other until the box is full.

(2) Place about three inches of damp vermiculite and perlite mix in the bottom of the box. Prepare the cuttings roughly to size and soak in water with some Formula 20 added for about an hour. Remove excess water as much as possible, then set the cuttings in the box just like a cutting tray, only as tightly as possible. You are then able to air the cuttings and give them an occasional misting. It is essential that this box be placed in a cool place in the vehicle, away from any sun shining through the glass windows. From experience it is quite easy to produce a heap of compost even in an insulated box. The cuttings are then prepared as normal on return, usually set in ⅓ German peat and ⅔ perlite, to which is added garden lime at the rate of 6 lbs per cubic yard. I usually set all of my cuttings in 1½ or 2 inch standard tubes packed in wire trays. At the present time I set my cuttings in an open 50% shade house under an intermittent leaf type mist unit. The only difference from most mist units is that I use B type mist nozzles at 6 ft centres. I do not use any form of bottom heat as most of my propagation is done during summer and in my situation the cost is not warranted.

QUEENSLAND NATIVE PLANTS WORTHY OF CULTIVATION

Agapetes meiniana. First discovered on the summit of Queensland's highest mountain range Mount Bellenden-Ker by Sayer and Davidson in 1887, *Agapetes meiniana* is still a little known plant in cultivation or in its natural habitat Belonging to the family Ericaceae, which includes the well known azaleas and rhododendrons, Australia has only four genera in this family — *Gaultherian* and *Pernettya* from the alpine areas of Tasmania, and *Agapetes* and *Rhododendron* from the high altitude areas of the Bellenden-Ker mountain range *Agapetes meiniana* is a rather unusual plant with bright red tubular flowers, usually in groups of three along its rather thin arching branches The flowers hang below the attractive lanceolate to ovate dark green shiny leaves which are a lighter shade underneath As I have not had the pleasure of visiting the Bellenden-Ker ranges, I know little about its natural habitat It is reported to grow at altitudes above 1,000m as an epiphyte in the forks of large rain-forest trees and occasionally out of rock crevices Although only limited numbers of this plant are in cultivation, it appears to grow quite well from Cairns to Brisbane if grown as a hanging basket plant in good shading The plant appears to produce a swollen underground stem from which the long slender arching branches are produced This plant has been successfully propagated from seed and from tip cutting about 10cm long, either under mist or in a cold frame Coming from a high altitude, this plant should prove very suitable for southern states

Rhododendron lochae is from the same habitat of Bellenden-Ker ranges as the *Agapetes* and is well known in cultivation throughout Australia and overseas In nature it is a large scrambling shrub to 5m, often on exposed rocky areas and usually found above the 1000m altitude A cultivated plant is usually a lot more compact reaching about 2m in height The red bell shaped flowers 3cm across and 5cm long are usualy borne in terminal clusters of up to six flowers This species can be propagated either by seed or tip cuttings in summer with the aid of mist and bottom heat Although originating in Queensland it is more suited in cultivation to Victoria and Tasmania It has also been grown in cool, shaded gardens in Brisbane

Eucalyptus ptychocarpa. Most native plant enthusiasts in coastal Queensland at some time or other have tried to grow the West Australian red flowering gum *E ficifolia* without success It seemed the only eucalypts suitable for cultivation were white flowered ones Then we were blessed with two striking coloured flowered euclaypts from the tropics being brought into cultivation They were *E ptychocarpa* and *E miniata E ptychocarpa*, the swamp bloodwood, is found across the top of the Northern Territory and in the Kimberley Region of Western Australia This eucalypt has been successfully cultivated in all areas of coastal Queensland over the past 10 years Most of the propagation has been from seed While the large, soft seed germinates readily during the summer months, no guarantee can be given to the flower colour, which ranges from white to pink to deep red By collecting seed from isolated trees of good deep pink to red colour forms, most of the seedlings, which usually flower in three to four years, are of good colour It is a fast growing tree of 10 to 20m that requires a moist position in the garden and heavy watering during dry periods The large terminal flower heads are produced in abundance from summer through to autumn The foliage, as well as the large clusters of large, woody ribbed seed capsules, are an added attraction of this plant This is the only red flowering eucalypt that I would recommend for coastal planting in tropic and sub-tropical Queensland

Eucalyptus miniata is an outstanding orange-flowered eucalypt with a natural range across the top of Australia growing in open forest and sandstone outcrops It requires drier conditions in cultivation than *E ptychocarpa* but the tree has been successful in northern coastal areas down to Brisbane provided it has good drainage In good conditions it will reach a height of 10 to 20 m with a persistant scaly papery bark in colours of grey and red for ⅓ of the trunk, above

this the trunk is usually smooth and light grey in colour It is usually propagated by seed and it flowers in axillary umbels of 3 to 7 large orange flowers in autumn to winter when three years old. The large fluted seed pods 3 to 8cm in length by 2 to 4cm in breadth require 12 months to ripen and usually produce 6 to 8 viable seeds up to 6mm diameter

Bombax ceiba. Silk cotton tree. (Figure 1) A large tree often 18m in height and having a fairly wide spread The species grows on moist, but well-drained hillsides, or deep alluvials along water courses It is deciduous and usually flowers before the appearance of new foliage. The branches have many stout conical prickles The large 10cm bright red cup-shaped flowers appear in great numbers during late winter and early spring, making a spectacular display. The flowers are usually full of sweet tasting fluid It is not certain if this is all nectar, or water collected from rain Propagation is by seed or cuttings taken when flowering has finished

Buckinghamia celsissima: Ivory curl flower is extensively used in Brisbane as a street tree where it maintains a height of 5 to 10m and a spread of 3 to 6m It also makes an excellent garden tree as it responds to regular pruning after its summer to autumn flowering period Natural distribution is rain-forest coastal ranges from Mt. Spec to Cooktown Flowers which cover the entire tree are sweetly scented, long creamy white racemes 10 to 20cm long and 3 to 4cm in diameter This tree sets seed freely and it is usually ready for collecting by early winter The seed is oval and papery and very thin and germinates readily if set in spring Tip cuttings taken from new growth after pruning, or from natural spring growth will strike under mist. As seedlings flower at an early age, this is the best method of propagation. It is successful as far south as Melbourne

Harpullia pendula Queensland tulip wood A widespread rainforest and coastal river tree along the east coast of Queensland and Northern New South Wales It has been used successfully as a garden, street, and park tree It develops into a medium height good shade tree with a dense rounded canopy There are a large number of two-lobed fruits which are yellow, orange or red in colour during the winter period These then split in early spring to reveal a large shiny black seed which germinates readily if planted in a warm, moist atmosphere

Nauclea orientalis Leichardt tree A large spreading tree occurring in rain-forest and low wetland areas from Shoalwater Bay to Cape York In cultivation in open areas, it tends to grow somewhat smaller, about 10 to 12m in height and is semi-deciduous during winter New growth appears in spring to give the tree a dense canopy of large heavily-veined leaves About Christmas the unusual 5cm round orange ball flower spikes with numerous small pink flowers appear on current season's growth Propagation is by seed or cuttings taken during the summer period

Graptophyllum excelsum Scarlet fuchsia A tall multi-stemmed shrub with glossy dark green foliage growing to a height of 3m Usually found growing on rough rocky hillsides that are well drained in central and northern Queensland This plant has adapted quite well to cultivation and, with regular pruning and watering, produces an attractive shrub which flowers throughout the year The main flush of bright scarlet flowers occurs in spring It is easily propagated by tip cuttings all yar round

Darlingia darlingiana. This species occurs naturally in rainforest areas of North Queensland around Mt Spec to the Daintree River where it grows to a height of 30m However, in southeast Queensland it has proved to be a successful garden tree keeping to a height of about 5 to 8m with a 2 to 4m spread It has attractive large leaves and flowers profusely in late spring with multiple upright spikes of white flowers, 20cm long and 5cm dia. It is usually propagated by seed as cuttings are usually extremely slow to root and have a very low success rate The tree is frost tender but has been grown in protected areas as far south as Melbourne

Figure 1. *Top left:* Flowers of *Bombax cieba*. *Top right:* Fruits of *Elaecocarpus grandis*. *Bottom:* Flowers of *Millettia megasperma*.

Elaeocarpus grandis Blue Quandong (Figure 1) A large attractive tree with, in nature, a buttressed trunk to 30m In open garden situations, it rarely exceeds 12m with a spread of 6m Its growth habit is most attractive producing radial branches at about every 2m of trunk growth giving the tree a pine-like appearance The leaves are large elliptical shaped with a finely serrated margin The old leaves have the added attraction of turning to red autumn colours before falling The tree flowers very heavily on the branchlets in masses of greenish-white, hanging bell flowers in autumn These are followed by a heavy crop of 2 to 3cm round green berries that turn bright blue when ripe The blue berries hold on the tree for a period of many months In far north Queensland the fruit is the favourite food of the magnificent fruit pigeon and, on falling to the ground, they provide food for the cassowary The cassowary is a large flightless bird of the rainforest and has the answer for germination of the hard seed of this fruit After passing through the birds' digestive system the seeds germinate readily. Germination of the seed in a nursery takes from 1 to 7 years The trees' natural distribution is along the coast from Cooktown, North Queensland to Nambucca Heads, New South Wales

Eugenia leuhmanii. Small leaf lilly pilly or water gum (Figure 2) In nature, a large rainforest tree with distribution in the coastal rainforests of Northern New South Wales and Queensland In cultivation, it produces a small compact tree with foliage usually to ground level, 5m in height and 2 to 3m spread The lance-shaped foliage is dark green and dense The most outstanding feature of this tree is the brilliant pink to red colouring of the new foliage which colours the whole tree during early spring and after long periods of rain The flowers are terminal, small white pom-pom type and are followed by clusters of bright red pear-shaped fruits which are edible and can be made into jam The fruit usually contains one small round seed which germinates readily in moist conditions The seed has short viability and should not be allowed to dry out I usually clean all the pulp from the fruit and store in plastic bags as previously explained Tip cuttings also strike readily in about 12 weeks under mist This plant has been extensively cultivated in Queensland but should grow as far south as Melbourne It makes a fine, large, tub plant

Eugenia wilsonii is a straggly, sparsely branched understorey rainforest plant in its natural habitat in far north Queensland In cultivation in Brisbane it has produced a low, compact shrub 1 to 3m in height with the same spread It is multi-stemmed and has dense foliage, producing numerous large deep burgundy pom pom-like terminal flowers on cascading branches New season's foliage, produced at flowering time, is also bright red The fruit is in clusters of round, white berries with a single seed which germinates easily Cuttings of half-hardened, new-season's growth strike readily under mist This plant does best in a shaded, moist area, full sun has adverse effects

Oreocallis wickhamii Satin oak (Figure 2) Has often been regarded as one of the world's outstanding flowering trees but, until recently, very little use has been made of it in cultivation Its natural distribution on the tableland in north Queensland is under threat due to land clearing for farming on the deep red basalt soils It is a magnificent high altitude rainforest plant growing to 10m in open cultivation with large dense blue-green foliage Juvenile foliage is distinctive 3 to 6 lobed The orange-red to red flowers are produced in large numbers over the canopy to produce a striking result This species is usually propagated by seed although some results have been achieved with tip cuttings, but these are slow and of low strike rate Seedlings usually flower in 5 to 6 years Limited numbers have flowered as far south as Victoria It is highly recommended for garden and park planting but requires good watering during the drier period

Phaleria clerodendron. An attractive lanceolate foliaged lowland rainforest tree growing from Innisfail to Cairns in tropical north Queensland This tree grows to about 5m in Brisbane and is a useful garden tree for a shaded area It has the unusual feature of producing its clusters of fine tubular white flowers

Figure 2. *Top:* Fruits of *Eugenia leuhmannii. Bottom:* Flowers of *Oreocallis wickhamii.*

below the foliage, back along the stems, branches and trunk to the ground level The flowers are followed bright-red, elliptical fruit which contains one seed that germinates readily. Tip cuttings are also successful. The fruit are also a food source for the cassowary

Hoya macgillivrayi. A strong succulent climber recorded only from the Iron Range of Cape York Peninsula in open rainforest areas, tree tops and along creek beds In nature the running stems grow to 6m in length In cultivation it has been grown as a container plant and allowed to climb on a trellis The outstanding feature of this plant is its flowers, usually borne in umbels of 6. The waxy red to purple flowers are up to 5cm across The flowers also give off a strong-scented perfume at night which may indicate it is pollinated by a night insect Most of the propagation to date has been by cuttings which are still in limited supply Propagation methods are the same as for exotic hoyas It is a desirable basket or tub plant, which requires a warm, filtered light location in Brisbane Glasshouse culture may be required during winter in the colder, southern states

Hoya* sp. *aff. rubida. This *Hoya* was collected from the Cape York Peninsula It appears to be more vigorous than *H. macgillivrayi* and the foliage is lighter green and furry to touch Flowers are not quite as large or waxy, about 3cm across and a pink-red colour Propagation and conditions as above but it appears to take winter cold better than *H macgillivrayi* Worthy of cultivation As yet only limited material is available

The Burra Range on the western side of the Great Dividing Range is a wealth of drier country grevilleas. The following are ones that will adapt to well-drained coastal gardens.

Grevillea decora. A dense or open, erect shrub to 4m height and spread with glaucous foliage It bears masses of dull-red, one-sided racemes along its branches The individual flowers of this genera are very large Propagation has only been from seed and these require scarification before setting

Grevillea pteridiifolia. A variable species occurring across North Australia It is available in prostrate form that produces true to seed, in shrub form and as an open, upright tree to 8m The Burra Range form is a tall shrub to about 3 to 4m and rather dense It produces heavy flowering of gold to orange toothbrush type flowers which are laden with nectar that attracts nectar feeding birds Seed set is heavy and, in nature, it is the food of seed-eating parrots, they can strip a plant of its seed rather quickly Propagation is mainly from seed and it is not unusual for seedlings to flower when 1-year-old This plant has been extensively grown in Brisbane as a garden and road side tree.

Grevillea sessilis. This is another another of the deeply-cut foliage, northern grevilleas Growth height is 2 to 4m with 1 to 2m spread Flowers are creamy, white-tipped with green on erect cylindrical racemes on the terminals of new season's growth. Propagation is usually by seed which needs to be scarified before planting. Seedlings usually flower in the first year of growth

***Grevillea* hybrid.** In the Burra Range there is a natural cross between *G pteridiifolia* and *G sessilis* It produces a compact, open shrub to 4m. Foliage is midway between the two, bearing the bronze-tip new growth of *G sessilis* The flower spike is cylindrical and buttercup yellow in colour Length and diameter of the flower is similar to *G sessilis*. Up to 12 plants of this cross were found on a field trip to the Burra Range in 1973. The best colour form has been grown successfully in Brisbane from cuttings A similar cross of garden origin from Myall Park, named *Grevillea* 'Sandra Gordon', is readily available on the local market, but it differs in the fact that this cross is lighter in colour and the flower has a flat back on it The growth habit is similar to *G pteridiifolia*. It has the advantage of being more floriferous but the disadvantage that it is a larger tree to 6m with a spread of 5m I think there is room for both of these hybrids on the market Propagation is from tip cuttings of new growth during summer

Melaleuca leucadendron. Weeping tea tree This is a large weeping broad or narrow-foliaged paper-bark tree to 15m ın height It occurs along river banks and flood plains from Rockhampton north along the entire Queensland coast, including the Gulf of Carpentaria Thıs large tree is noted for its impressive white paper-bark trunk and the masses of white bottlebrush type flowers produced during the winter months to early spring. The flowers are lightly honey-perfumed and attract nectar-feeding birds and insects The outer branches of some plants, especially the narrow-leaf form, are very pendulous This plant ıs usually propagated from seed but cuttings taken from the new spring growth will strike under mist This plant ıs extensively used ın Brisbane gardens and for park plantings, it is a far superior paper bark than *M quınquenervıa* that is normally planted in the south

Melaleuca viridiflora. Broad-leaf paper bark Is an open, upright tree to 8m in cultivation Because of its upright growth it is ideal for group planting in a small area It does best in a wet position as it is normally found in low flat areas that become swampy during the wet summer season Flowering is usually during winter, the normal colour of the bottlebrush-type flower ıs greenish-yellow, from which the plant derives ıts name However, there are many different colour forms available from soft pink to deep burgundy red, as well as white These colour forms are well worth propagating. They can be struck under mist using the new growth tip that appears after flowering in spring Natural range is from Maryborough north along the coast

Bowenia serrulata. Byfield fern This is not a true fern but a member of the Cycad family Other than the attractive leaf stems 1m high, most of the plant is below ground level. The underground tuber is usually about the size of a football and can be up to 30cm below the surface. The leaf petioles produce bright glossy green stiff serrated leaves along their multiple sub-stems These are noted for their long life even after being cut The fruiting cones are produced on female plants at ground level. This plant is in danger of being wiped out by pine forests and development. It is a slow-growing plant in Brisbane gardens and may require pot culture in the southern states. In nature it is restricted to the Byfield and Shoalwater Bay areas of the Central Queensland Coast.

Blackdown Tableland ıs an elevated plateau ın Central Queensland which is lıke an oasis in a semi-arid region Its higher rainfall makes it a place where a lot of coastal plants and unusual indigenous plants are found. The area has numerous waterfalls and watercourses. Here is found an unnamed species of *Lıvıstona* palm Also growing here is a small semi-prostrate callistemon, as yet undescribed.

***Callistemon sp.* (Blackdown Tableland).** This is a low-growing, fine-leafed plant to 35cm in height and 1 to 2m in spread, growing in places amongst the rocks right to the water's edge. Its flower is a short, bright-red bottle-brush with striking yellow-tipped stamens It is easily propagated by cuttıngs and seed, but cuttings are recommended for maintaining the best plants of the species The plant has been successfully cultivated from Townsville to Brisbane

Grevillea longistyla. This low shrub-type grevillea is also on the drier, open-forest areas of the tableland and has been grown in coastal gardens, provided it is well-drained in elevated beds The flowers are large, orange-red, and borne in erect terminal racemes during late wınter to early summer Propagation is either by tip cuttings or by seed, that requires scarifying before planting

Acacia macradenia. An outstanding tall and spreading wattle to 3m with long, pendulous branches often to ground level Its common name, zig-zag wattle, is derived from the regular bending of the stems at each leaf node Flowering is prolıfic along the branches in approximately 8cm racemes of large golden-ball type flowers amongst the long, broad, bright-green phyllodes during mid-winter to early spring Seed set is usually heavy and is the main method of propagation used. The seed requires treating by the boiling water method or by scarification for successful germinatıon Natural distributıon of this plant is from Roma to

Clermont in Queensland, and has been grown in gardens from Townsville to Melbourne It will not survive the Canberra winter.

Acacia bancroftii. Restricted in nature to a small area from Kingaroy to Clermont in Queensland This small branching tree 3 to 5m in height with a slightly lesser spread and attractive blue-gray broad phyllodes is worthy of more cultivation in the drier areas of Queensland than at present Flowering is during winter in long racemes of up to 20 bright yellow globular flowers which make it a excellent acacia for garden use This species is usually propagated by seed, treated by boiling water or by scarification Seed of this species is not readily available because of the isolated distribution. This plant has been successfully cultivated in dry inland towns and the drier coastal regions of Rockhampton and Townsville

Lepidozamia peroffskyana. This is an attractive plant with palm-like, dark-green, glossy, pinnate leaves 2 to 3m in length, rising in whorls from a central crown at the apex of a short, extremely slow-developing trunk Natural habitat is restricted to the rainforest mountain ranges in S.E. Queensland and Northern New South Wales The palm-like apearance of this plant and its slow growth rate make it ideal for tub or indoor culture Belonging to the Cycad family, male and female cones are produced on separate plants The female cone is extremely large, 50 to 60cm long by 25 to 30cm in diameter Seed produced in this cone is about the size of a small hen's egg and has a bright yellow to orange covering The seed will usually germinate where it falls to the ground if moisture conditions are right In cultivation the seed is best set half exposed but can take up to 12 months to germinate

Millettia megasperma. Native wisteria (Figure 1) A vigorous climber from rainforest and creek banks, it can be easily grown in sub-tropical regions on a trellis or as a "standard" where it can be controlled by pruning In its natural habitat, Fraser Island, Queensland, to Ballina, New South Wales, it can cover very large trees. Spring flowers are 15cm upright racemes of mauve-purple-white which occur on a terminal Propagation is by the large, red seeds which are encased in a hairy, large bean-like capsule, usually containing 4 to 6 seeds.

Stenocarpus sinuatus. Wheel of Fire An attractive, deeply divided or entirely foliaged, tall tree which does well in cultivation, growing 8 to 10m. Natural habitat is from northern New South Wales, along the Queensland coast to Paua, New Guinea, in rainforest areas Flowers are the most distinctive feature of this tree, being bright red in umbels of 6 to 20cm in diameter, resembling a cart wheel Flowers are usually found on the old wood Propagation is usually by seed, the papery winged seeds are tightly packed in 6 to 10cm cigar-like capsules This plant has been used with mixed results as a street tree in Brisbane It is a common tree in older Queensland gardens

Backhousia citridora. Lemon ironwood For a tree to add lemon fragrance to a garden this plant is a must It is a small, densely leaved tree with foliage to ground level, 5m in height and 3m spread in garden cultivation The foliage when brushed or crushed emits a strong citrus odour Flowering is in summer with masses of white individual flowers in clusters on terminal branches. Natural range is from Brisbane to Mackay, usually in rainforest or west areas. Propagation is by tip cuttings or layering Seed propagation is difficult due to the trouble of finding viable seed and it is advisable to plant the entire capsule. It can be grown as far south as Melbourne

Barklya syringifolia. A shapely, dense-crowned small rainforest tree with bright green, glossy heart-shaped leaves Grows naturally from Brisbane to Mackay in coastal rainforests. The flowers are bright yellow to orange, held on a terminal, cylindrical raceme about 20cm long, forming a dense panicle The whole surface of the crown becomes a blaze of colour during spring into summer This plant is usually propagated by seed which are ripe about 4 months after flowering

Codonocarpus attenuatus. Bell tree A tree of 8 to 10m with grey, smooth bark and numerous pendulous slender branches with long, lance-shaped leaves It is usually found growing on the high dry river banks of the Brisbane river in the south to Central Queensland The tree is worthy of garden cultivation mainly for its weeping growth habit and the unusual bell-shaped seed capsules it produces in masses along the branches These capsules are about 3cm in length and 2cm in diameter When ripe they break open like layers of a paper Christmas bell to release a small kidney-shaped, hard, black seed. The seed is used for propagation Although seeds are numerous, germination is poor. Best results have been obtained by burning over the seed To my knowledge cuttings of this plant have not been tried

Davidsonia pruriens. An attractive single or multi-trunked upright rainforest tree to 8 to 12m with large pinnate leaves and elliptical leaflets to 20cm. Natural distribution is from northern New South Wales to North Queensland in rainforest areas The flowers produced on 30 to 35cm pendulous panicles are insignificant, but are followed by clusters of large plum-like fruits that turn deep purple when ripe, usually in late summer to early winter. The fruit has rich, red edible flesh and is used for jam making The new foliage and fruits are covered with a thin coating of short brown hair which causes irritation to some people Useful as a garden plant and for indoor use while still young It has been grown as far south as Melbourne

Evoida (Euodia) elleryana. This attractive dark green, trifoliate-leaved rainforest tree is ideal as a garden specimen tree in tropical and sub-tropical climates. It requires moist conditions and grows 8 to 15m in open cultivation. In its natural habitat from the Richmond River, New South Wales to North Queensland and Papua, New Guinea, it can reach a height of 30m The pink to mauve flowers are borne in dense panicles along the branches at each leaf node on last season's growth The flowering period is during the summer months for about 6 to 8 weeks The flowers are followed by attractive green seed pods which remain on the tree until early winter when they split to reveal a shiny hard, black seed. This seed germinates readily if sown in late winter to early spring Tip cuttings in summer are also successful

MACHINE PREPARATION OF HARDWOOD CUTTNGS

BEN SWANE

Swane's Nursery
Dural, New South Wales

I am sure many plant propagators still measure each individual cutting and still use secateurs (pruning shears). All the secateurs I have used in the past bruise the ends of every hardwod cutting and tend to split them, especially when the cutting material is of a large diameter, e.g. *Platanus* (plane tree).

I believe that better and more uniform cuttings can be produced by sawing; this is practicable even for small growers, especially for those who grow hardwooded plants, such as plane trees. Sawing of hardwood cuttings is clean and fast and leaves no bruising of the ends of the cutting.

The experience I have had with hardwood cuttings includes the following plants:

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The experience I have had with hardwood cuttings includes the following plants:

roses (stock)	quince stock
plum (stock)	*Lagerstroemia*
poplar trees	*Hibiscus mutabilis*
plane trees	*Ligustrum* (stock)
Fraxinus (stock)	mulberry (Hick's)

I have been sawing rose cuttings for 10 years.

I would like to point out some of the normal methods where each cutting is made individually with secateurs.

First — time is, of course, the first disadvantage (time is money)

Second — the hard work involved. It is constant and tiring on wrists (although air machines have eased this burden).

Third — the size of the wood used for cuttings can be increased when high speed saws are used.

The saws generally used are very high speed and are usually fitted with blades having 9 to 10 teeth to the inch without any set of the saw. The saw I have chosen is a standard Makita 9″, single phase, 3,500 to 4,000 rpm. A firm bench with a moving section or table has been built around this saw. This allows the cutting material to be held on either side of the saw and well away from danger. The saw has no respect for fingers — great care should be taken at all times.

Many hours of grading can be saved by developing a handling system. If you take the first cut off the bundle of wood the cuttings produced are No. 1 grade. The next cut gives the No. 2 grade and so on. The grading is fairly even and a good idea of the number of cuttings made can be obtained if they are placed in a simple wooden box such as that in Figure 1A. These boxes are inexpensive; they also keep cuttings in a confined area, make them easy to handle, are used to bind the cutting material and, again, save on hand methods.

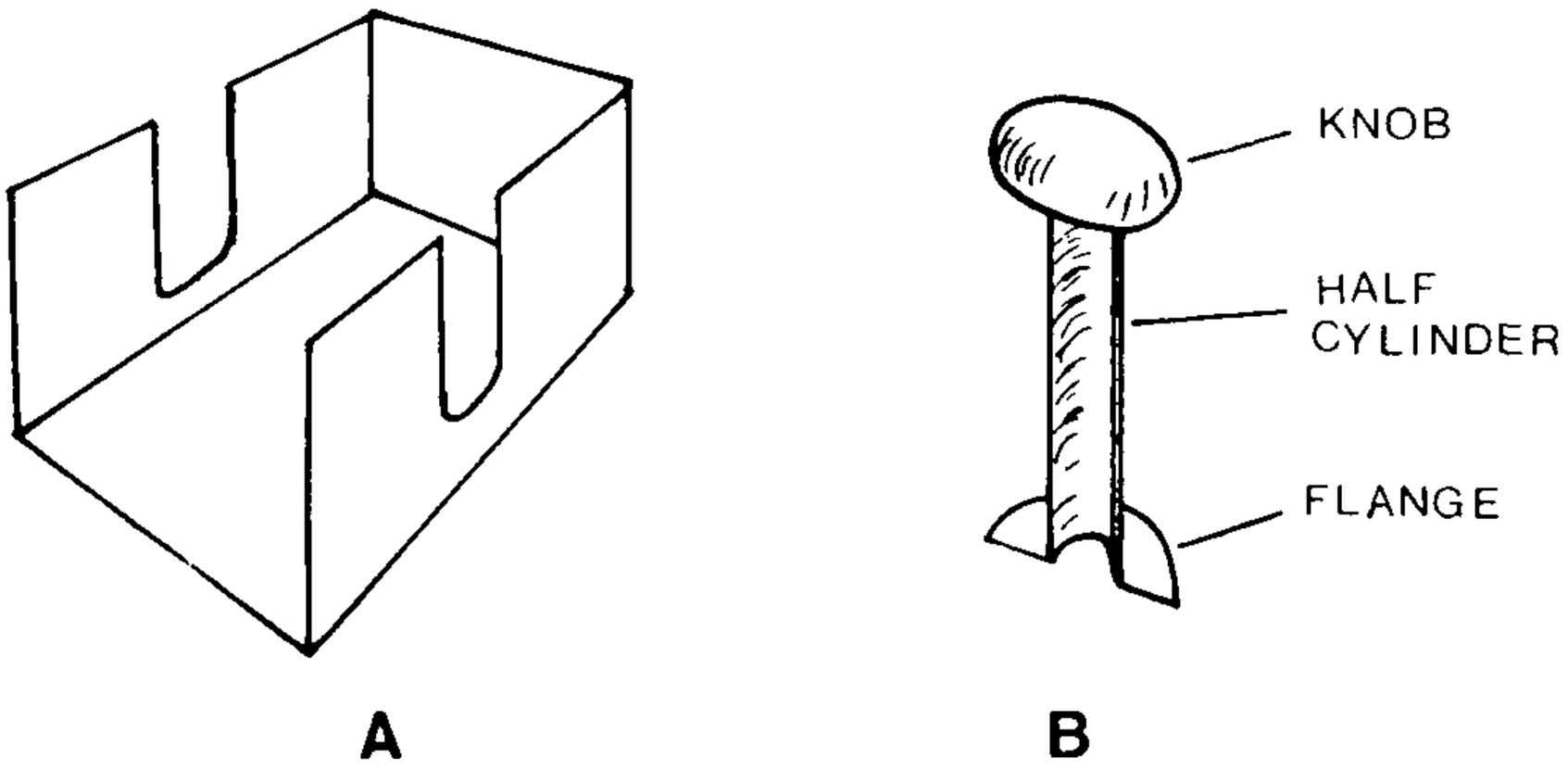

Figure 1. Aids for preparation and planting of cuttings A Open-ended box to hold cuttings during preparation and to speed tying. B Planting aid to save palms of operator's hand and to ensure uniform depth of planting

The next step in the preparation of cuttings is their storage until planted and this is very important.

If boxes are to be used they should always be treated with 1% sodium hypochlorite (used in swimming pools) and stored about ground level, well lined with clear plastic and unprinted paper inside the plastic liner.

After cuttings have callused they can be machine-planted or hand-planted. Hand planting can be assisted by the use of a small tool (Figure 1B) to save palms of the hand and to keep cuttings at the one depth for the task of budding, where necessary. All of the hardwood cuttings are planted through tar paper which is laid several months prior to planting. This paper is laid by machine and pre-punched for correct spacing of cuttings. The paper creates a capillary action and keeps the base of the cuttings moist.

GETTING DOWN TO BUDDING

DEANE M. ROSS

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One problem that all nurserymen who grow their plants in the open fields have in common is that they have to do much of their work at ground level. Planting, weeding, shaping, budding, heading off, etc. all involve getting down to ground level by bending, squatting, kneeling, crawling, or, if you are lucky, sitting. Before long, every one of these positions becomes insufferably uncomfortable, and you are left wishing that you were growing your plants at bench height in the comfort of an air-conditioned propagating room.

Some of the faster "ground-bound" operations, such as planting and digging can be done by tractor-mounted rigs, but the slowest of all operations, that of budding, seems to have defied all efforts to make the job tolerably comfortable. And a comfortable working position, by its nature, makes for greater efficiency and higher morale.

Some people will argue that by growing the product in containers it will overcome all of these difficulties in one fell swoop, but it seems to me a very radical cure to have to change the whole cultural technique if the only problem is the comfort (or lack of) for the working position.

Many budding positions and aids have been tried. The most common, and the fastest, is to stand feet astride the row and bend from the waist. Other positions are to kneel on one knee, to

The next step in the preparation of cuttings is their storage until planted and this is very important.

If boxes are to be used they should always be treated with 1% sodium hypochlorite (used in swimming pools) and stored about ground level, well lined with clear plastic and unprinted paper inside the plastic liner.

After cuttings have callused they can be machine-planted or hand-planted. Hand planting can be assisted by the use of a small tool (Figure 1B) to save palms of the hand and to keep cuttings at the one depth for the task of budding, where necessary. All of the hardwood cuttings are planted through tar paper which is laid several months prior to planting. This paper is laid by machine and pre-punched for correct spacing of cuttings. The paper creates a capillary action and keeps the base of the cuttings moist.

GETTING DOWN TO BUDDING

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One problem that all nurserymen who grow their plants in the open fields have in common is that they have to do much of their work at ground level. Planting, weeding, shaping, budding, heading off, etc. all involve getting down to ground level by bending, squatting, kneeling, crawling, or, if you are lucky, sitting. Before long, every one of these positions becomes insufferably uncomfortable, and you are left wishing that you were growing your plants at bench height in the comfort of an air-conditioned propagating room.

Some of the faster "ground-bound" operations, such as planting and digging can be done by tractor-mounted rigs, but the slowest of all operations, that of budding, seems to have defied all efforts to make the job tolerably comfortable. And a comfortable working position, by its nature, makes for greater efficiency and higher morale.

Some people will argue that by growing the product in containers it will overcome all of these difficulties in one fell swoop, but it seems to me a very radical cure to have to change the whole cultural technique if the only problem is the comfort (or lack of) for the working position.

Many budding positions and aids have been tried. The most common, and the fastest, is to stand feet astride the row and bend from the waist. Other positions are to kneel on one knee, to

kneel on both knees, to squat, and even sit on the ground. Various budding seats have been used, including one about 1 metre long, along which you slide, and a one leg stool, sometimes strapped onto the budder.

In my case, I suffered budding in every conceivable position for many years until about eight years ago, when I developed my "bud-mobile." It is based on an idea I learned from Howard's Rose Nursery in California. The prototype was a device which was adjustable in all directions and, from the experience gleaned from this model, I made the one I have used ever since.

It is made of two standard bicycle wheels (cheap and easy to get), the frame is made of light tubular steel, and the skid underneath the kneeling pad provides the vital third point which steers the "bud-mobile" (Figure 1). It weight approximately 12 kg. The budder kneels on a pad some 20 cm above the ground, and leans his chest over a contoured pad with his hands free to reach down either side. The pads are 10 cm thick foam plastic, covered with vinyl material and are set obliquely across the row at an angle of from 30 to 50° depending on the crop and the preference of the budder. The net result is that the budder is supported at about the same position as the popular and fast "stand over" position, but closer to the work, thus giving him a better view.

I would emphasize that you should put a lot of attention into getting just the right amount of "give" in the two pads so that you are comfortable. You can very well try inflatable cushions as an alternative.

It is important that the chest pad be able to be raised or lowered to fit the particular budder, typically from 45 cm to 55 cm from the kneeling pad. To move the "bud-mobile" you simply press sideways with your toes.

One particular aspect that I like about the "bud-mobile" is that you can carry your budding supplies and equipment arranged in a convenient layout around you. Budwood, ties, sharpening strop, secateurs, rag or towel, radio, sunshade, can be arranged near at hand.

I have been using my "bud-mobile" for the past eight years and, for me, it has turned budding into a reasonably tolerable chore. I am sure that anyone else who does not possess the suppleness of a gymnast could also benefit from it.

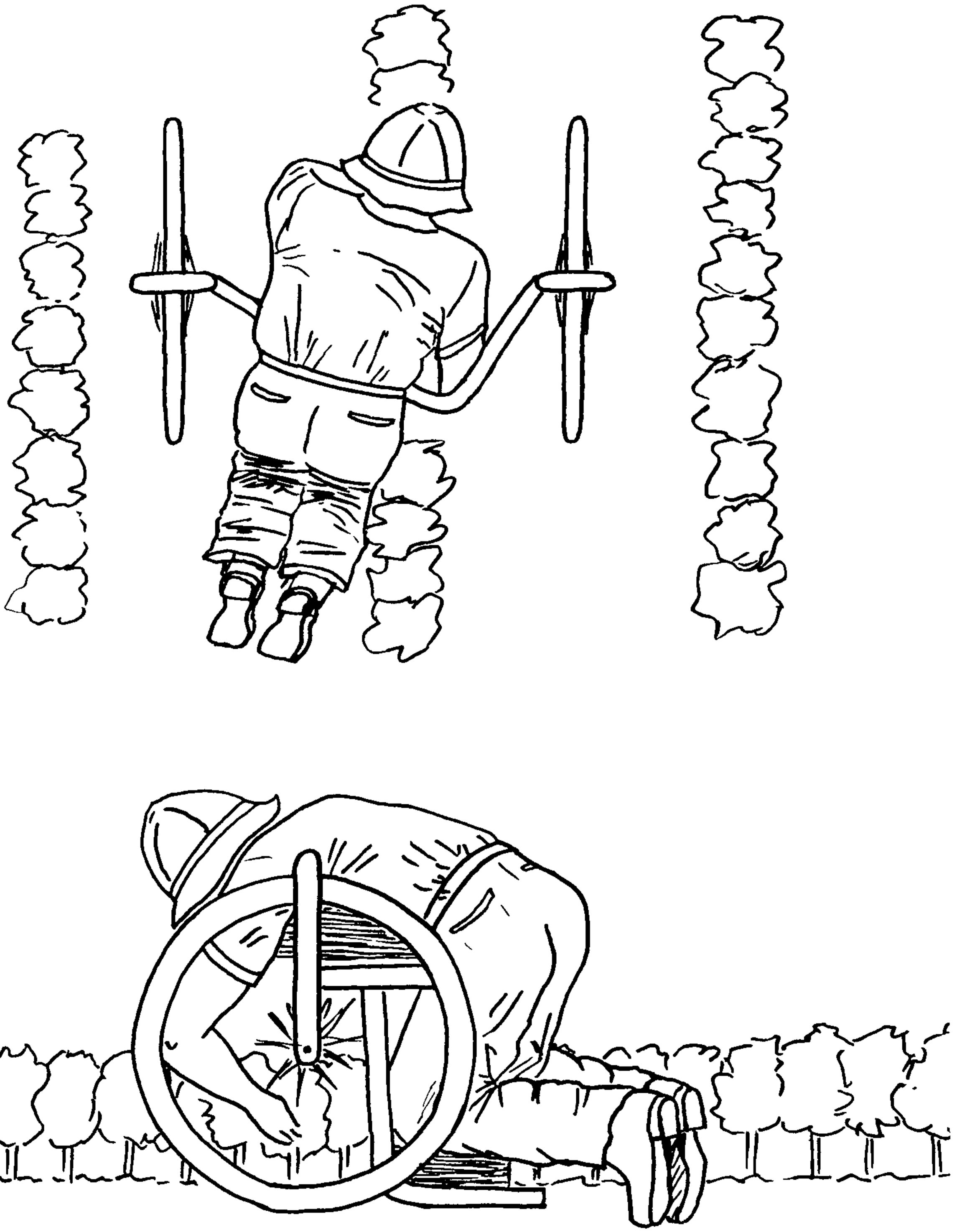

Figure 1. Bud-mobile An aid to more comfortable field operations, such as budding

USE OF WEEDICIDES IN THE NURSERY

ROD TALLIS

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Arcadia, New South Wales

Weed eradication and control have always been a major problem for nurserymen producing ornamental trees and shrubs. As growing media and nutritional programs have improved over the years providing better plant growth, weeds have also prospered. In field production, cultivation to prevent weeds is possible but pulling of the weeds by hand is very slow and expensive. particularly with escalating wages. Also the cost of maintaining weed-free pathways or tracks has become astronomical.

In order to beat the ever increasing weed situation in nurseries, Casuron granules, Roundup, Tenoran and Gesatop (Simazine) were used in weed control experiments during 1980 with the following results.

GROUND WEED CONTROL

Casuron. I had a bad infestation of a very soft, fast-spreading weed called bitter cress *(Cardimine pennsylvanium)* growing in and around tube growing shadehouses. Damp conditions continually cause this weed to become a real plague.

Casuron granules were applied at the rate of 220 grams per 10 sq. metres. Although Casuron gives off a vile smelling gas which tends to be worse under enclosed conditions, such as shade houses, the long term effectiveness of the chemical is excellent. A full 8 months control was gained with one application. Under no circumstances should Casuron be used in glasshouse enclosures.

Roundup. Roundup has been used extensively for pathway weed control in nurseries because of its effectiveness in killing most weeds and grasses. The cost of Roundup has been rising rapidly and it is becoming prohibitively expensive to use. I tested urea used with Roundup to see if the rate could be decreased and the cost reduced.

The usual rate for Roundup is 1700 ml to 200 litres of water with no wetting required. I was able to get excellent weed control by using only 800 ml Roundup per 200 litres of water when I added 1000 ml of wetting agent (Agral 20) and 4 lbs urea. With only 600 ml, Roundup control was only reasonable to poor.

WEED CONTROL IN CONTAINERS

The questions that arise are:

a. What cultivars of plants can withstand a herbicide treat-

ment?

b. How long will the weed control period last?

c. At what strength should the chemical be used?

d. To what extent does stunting of the plants occur

Two herbicides that seem to be fairly widely used are Tenoran and Gesastop (Simazine). To evaluate these herbicides a group of 350 plants of 70 cultivars (Table 1) was set aside and treated with various strengths. Included in these cultivars were Australian natives, ornamentals, shrubs, trees, and conifers.

Table 1. Plants used to test susceptibility to Tenoran and Simazine "X" indicates plants that were very susceptible to herbicide applications

Abelia × *grandiflora*
A grandiflora, variegated cv
Acacia baileyana
Araucaria heterophylla
Archonto phoenix alexandrae
Asparagus densiflorus 'Sprengeri'
A setaceus (Syn A plumosus) A 'Nanus'
Banksia integrifolia[x]
Bauera rubioides[x]
Betula pendula
Buxus sempervirens[x]
Callistemon 'Captain Cook'
C 'Endeavour'
Callitris sp
Casuarina cunninghamiana
Chamaecyporis pisifera 'Boulevard'
cyanoviridis
Choisya tenana
Cordyline sp
Cuphea hyssopifolia
Cupressus 'Brunniana' (?)[y]
C sempervirens[x]
C sempervirens 'Swane's Golden'
C 'Skyrocket' *(Juniperus scopularum* 'Skyrocket'
Erica canaliculata[x]
E 'Stumpy'[y]
Eriostemon sp
Euonymus sp [x]
Eutaxia sp.[x]
Ficus elastica 'Decora'
F pumila[x]
Gardenia augusta (Syn *G florida)*
Grevillea biternata
G 'Canberra Gem'
G 'Firebird'
G "Pink Pearl'
G 'robusta[x]
Grevillea rosmarinifolia
Hakea salicifolia
H buxifolia[x]
H 'Inspiration'[x]
Hedera helix 'Gold Dust'
Hypericum[x] *mosetanum* 'Tricolor'
Jasminum polyanthum
Juniperus conferta
J procumbens
Lantana 'Chelsea Gem'
L 'Snowflake'
Lavendula sp.[x]
Leptospermum 'Burgundy Queen'[x]
L petersonii (Syn.: *L citrinum)*
Liquidambar sp
Lonicera nitida
Melaleuca armillaris
M incana
Nandina domestica 'Purpurea' ('Nana')
Phlox, alpine
Phoenix roebelenii
Photinia robusta
Pittosporum (Variegated cv.)[y]
Platycladur (Thuja) orientalis *Beverleyensis Aurea*
Privet, golden[x]
Rosmarinus sp
Sapium sp
Schnus-molle
Thryptomene australis
Thusa occidentalis 'Rheingold'
T 'Swellii' (?)[y]
Trachelospermum jasminoides
Vibernum tinus
Westringia fruiticosa (Syn *W rosmariniformis)*

[x] Susceptible to herbicides
[y] Bot Ed unable to verify name

Herbicides were applied between 4 and 5 p.m. on 2nd April, 1980 with weather changing from sunny to cloudy. Irrigation one hour after spraying washed the herbicides off and four hours later a shower of rain was received. Results were compiled 6 hours later.

Three strengths of each chemical were used. All pots contained some grass and weed vegetation when sprayed. The following observations were made.

Simazine

23 ml per 15 l knapsack — poor weed control.

35 ml per 15 l knapsack — excellent weed control.

44 ml per 15 l knapsack — excellent weed control but severe stunting of potted plant.

The first effects of Simazine showed up 5 weeks after application and weeds continued to die over the next 3 weeks. There was very noticable stunting of almost all potted plants. The conifers were the only ones showing no ill effects. Susceptible plants were affected by all three concentrations of herbicide but the stunting was greater with the higher concentration.

Tenoran

3½ tablespoons per 15 l knapsack — no weed control

4½ tablespoons per 15 l knapsack — partial control

6 tablespoons per 15 l knapsack — control of soft weeds

(6 tablespoons/knapsack is equivalent to 6 lbs/acre)

All Tenoran treatments were unsuccessful and only achieved partial control of soft weeds and grasses. More vigorous weeds continued to grow but were very stunted. The potted plants seemed to be a little stunted. It seems that stronger rates of Tenoran are needed for successful weed control.

Of the 350 plants used in these trials only 30 were killed by the herbicides. The rest were still alive 6 months after treatment.

STUD BUDS — THE FRUIT VARIETY FOUNDATION AND ITS FURTHER APPLICATION TO ORNAMENTAL HORTICULTURE

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The term "stud buds" has been coined in the context of "fvf" or "Fruit Variety Foundation" to denote propagating material which has been tested for virus content and for horticultural characteristics.

The Problem. Viruses and virus-like diseases can affect members of both plant and animal kingdoms. They are considered to be parasitic entities but they are so small they can be seen only through the electron microscope.

Symptoms in virus infected plants vary widely. They can occur on any part of the plant although most often are seen on leaves and flowers. Sometimes they are symptomless or nearly so and not seen at all. On leaves, viruses can cause changes in colour, shape and size. On stems they may shorten internodes or cause flattening or swelling or defoliation of terminal growth or pitting of the wood under the bark. Flowers may be variegated or transformed into leafy structures. The fruit may be deformed, show colour changes, be russetted, or marked in other ways. Roots may be killed or show growth abnormalities. Incompatibilities can occur between scion and rootstock. Growth can be reduced as can cropping.

Fruit tree viruses are commonly spread by the use of propagating material already infected. However, they are not usually transmitted by seed so that seedling rootstocks are generally virus-free, with stone fruits and avocados being two important exceptions. Insects, pollen and nematodes can spread some viruses. Thus the problem of virus transmission is greatest with vegetatively propagated species.

The Control. Virus diseases are controlled by preventing their spread, so that the use of propagating material that is not carrying harmful viruses is the principal method of control. Those disorders which are readily distinguishable by eye are easily eliminated by nurserymen and growers through careful selection of propagating wood. However, the insidious infections are only detectable by using special virus indicator cultivars and clones, called "indexing," by electron microscopy, or by serology. Hence the aim of fvf foundation plantings is to collect and maintain in a virus-tested condition, clones which have been tested for both virus content and superior horticultural characters.

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[1] Chairman, Australian Fruit Variety Foundation Committee

Why Virus-Tested and not Virus-Free? The term "virus-tested" is used deliberately as "virus-free" can only be used when the results of checks for *all* the known viruses are negative. "Virus-tested" is used where plants have been indexed as free from *particular* viruses, usually those of most economic significance.

There are two other reasons for using the term "virus-tested". Firstly some clonal material may be accepted into fvf even though known to be carrying some viruses of relative unimportance. Such material is still the best available and to await production of a clone completely free of all known viruses would be impractical and contrary to the aims of fvf. The second reason is that in some situations the absence of a mild strain of virus can allow the entry, usually by insect transmission, of a severe strain of the same virus with devastating results — in other words the presence of a mild strain of a virus can protect against infection by a severe strain. Probably the best known example of this situation is the need for citrus to carry a mild strain of the virus disease tristeza.

Some History. At the Australian Plant Pathology Conference in 1961, Dr. A.F. Posnette of East Malling Research Station, United Kingdom, outlined the new methods being developed to detect symptomless virus infection and also the technique of heat therapy employed to free plants of virus. In reporting on his visit, Dr. Posnette noted the wide distribution of virus diseases of fruit crops within the Australian industry. As a result, it was proposed that Australia should establish an isolated National Foundation Planting (previously called Repository) for the important fruit crops. From this planting propagating material was to be made available to associated multiplication units which would supply nurserymen with commercial quantities.

Various problems including interstate quarantine restrictions on the movement of plant material, staffing problems associated with the isolation of such a large complex and its cost resulted in the project being temporarily shelved. Following an informal meeting between horticulturists and virologists in 1970 the Australian Agricultural Council accepted a revised scheme proposing a number of Foundation Plantings which would utilise the resources then available in the different States rather than one single area. Secondly the individual States would be responsible for the multiplication of material for supply to nurserymen.

Another Committee. The present Fruit Variety Foundation Committee is a sub-committee of Standing Committee on Agriculture's Horticulture Committee. The latter comprises Chief Horticulturists (or their equivalents) from each of the six States, CSIRO, and representatives of the Commonwealth Departments

of Primary Industry and Health. The fvf Committee is drawn mainly from those same bodies, some of which provide virologists and some horticulturists. It meets annually and has responsibility for the general planning of Foundation Plantings, the financial management of facilities and staff, and the establishment of criteria for the nomination of fruit cultivars to the Foundation Planting.

This involves:

- maintenance of the foundation sources of virus tested clones of the major fruit cultivars for supply to multiplication units
- participation in international exchange of virus-tested clones
- continual rechecking of the virus status of admitted clones
- horticultural and virus testing of clones nominated for admission in collaboration with the States
- development, through research, of improved methods of virus indexing and of freeing horticulturally desirable clones from virus
- removal from the plantings of previously admitted clones found to have become virus infected or horticulturally unimportant.

The nomination of a candidate clone by a State Department or CSIRO to the Foundation Planting is accompanied by a record of its virus status with details of personnel doing the indexing tests and the conditions under which the material has been kept since last tested, as well as the classification of its horticultural characteristics.

The Foundation Plantings. After being granted admission to the Foundation Planting the material is retested for virus each five years under the present rules. Depending on experience, the period of five years may be extended. As superior clones are admitted so the superceded clones will be removed.

The various Foundation Plantings are supervised by the virologists and horticulturists of the States in which they are located. The salaries of some of these and of some technical staff are subsidised by fvf funds. In addition, the committee provides for one full time virologist who is located with the Victorian Department of Agriculture which has the responsibility for Foundation Plantings for grapevines and some stone fruits. New South Wales has Foundation Plantings for other stone fruits and citrus whilst an avocado planting is currently being built up. The Tasmanian Department of Agriculture operates the pome fruit planting. The numbers of clones currently held or conditionally approved for admission are:

Huonville (Tas)	Apples	74	*Gosford* (N S W)	Avocados	9
	Pears	12			
	Quinces	3			
Irymple (Vic)	Grapevines	115	*Dareton* (N S W)	Citrus	31
Burnley (Vic)	Peaches	68	*Rydalmere* (N.S W)	Cherries	23
	Nectarines	2		Plums	16
	Apricots	3		Almonds	2

Overseas, the two largest Foundation Plantings in operation are the IR-2 scheme in Prosser, Washington State, U.S.A. and the EMLA (East Malling-Long Ashton) scheme in the United Kingdom.

The Status of Ornamentals. At the 9th annual meeting of the committee in 1979 the decision was taken that ornamental clones within the genera covered by the present fvf scheme were eligible for admission to fvf in view of the potential for infection of commercial fruiting clones from such related ornamentals, but such admission was not to be at the expense of commercial fruits. Already 11 cultivars of virus-tested crabapples from East Malling are being nominated for inclusion in the Pome Fruit Foundation Planting. In addition nine ornamental cherry cultivars, also from East Malling, are likely to be nominated.

It is necessary to point out that, apart from the related species, virus disease etiology in most ornamentals differs from the commercial fruits in that insect-borne viruses are relatively common. Also the insect vectors associated with ornamental viruses are generally more efficient than those associated with fruit trees and this necessitates more frequent and thorough testing. Because of this there may be little to be gained from small outdoor virus-tested plantings of the majority of ornamental species. However, benefits would accrue to those grown under protected environment conditions, as has been convincingly demonstrated with carnations, and perhaps also to the well-managed larger outdoor plantings.

Overseas Schemes for Ornamentals. The concept of virus-tested ornamentals is well established overseas. In the United Kingdom the Nuclear Stock Association has presently available 83 virus-tested lines of chrysanthemums, 40 of carnations, 18 geraniums, 32 lilies and further schemes are being developed. In Holland the NAKB Inspection Service appointed by the Dutch Government operates schemes for hyacinths, tulips, freesias and nerines. Israel has government-operated schemes for carnations and *Gypsophila* while in the U.S.A. the University of California, Davis, has a scheme for roses, grapes, fruit trees, and Japanese flowering cherries. Also in the U.S.A. healthy carnations and chrysanthemums are produced by private enterprise, e.g. Yoder Bros. in California. South Africa also has a scheme for roses.

The Australian Situation with Ornamentals. So far, no proposals have been put forward for a national Ornamental Variety Foundation (OFV) as a sister scheme to fvf. At State level, Victoria has been most active with schemes for producing virus-tested cultivars of carnations, chrysanthemums and daphne. Similar schemes for roses, bulbous iris, gladiolus, violets, hyacinths and lilies are also being developed or evaluated.

Hibiscus and orchids are two ornamentals for which virus-tested material would benefit industry as in both, virus diseases are prevalent and increasing in incidence because of vegetative propagation techniques. Hibiscus mosaic virus is present in Australia. Although symptoms vary with cultivar; yellow veins, distorted flowers, and reduced leaf size commonly occur.

It does seem a good case can be made for a national scheme to cover roses because:

- they are susceptible to infection by a number of viruses;
- there do not appear to be any insect-borne or nematode-transmitted viruses of significance;
- being woody perennials, a scheme for roses could be somewhat complementary to the present scheme.

On the other hand:

- roses tend to wax and wane in fashion and there could be a problem of very high turnover affecting costs;
- many of the newer fancied roses are more susceptible to other diseases and this, too, could affect costs.

Costs. On the cost angle, as already suggested wtih ornamentals, there would be a much larger range of cultivars and species to be covered and presumably a more rapid rate of turnover. This would increase costs of an OVF compared with fruit. On the other hand, it should also increase income and so may be rather more than less favourable. Again, in contrast to the woody perennial fruit trees and viruses, carnation and chrysanthemum mother plants could be more costly because of their need to be propagated each year by cuttings while the bulbs are annuals and, therefore, have to be lifted and replanted each year. The rate of multiplication of the bulbous ornamentals is also usually slow although tissue culture techniques are improving the situation. Because of the risk of re-infection of mother plants it is considered essential to have an active tissue culture group to clean up any important clones that may be infected.

In an fvf was established for ornamentals, in the present situation Victoria has the greatest expertise because of its existing schemes. However their revenue from sales of cuttings from carnation and chrysanthemum mother plants is less than 10% of the cost of operating the scheme. For such schemes to be operat-

ed on a national basis considerable financial support would be necessary. The present fvf schemes for fruit commenced in 1971/72 with an annual budget of $30,000 and this has reached $100,000 for 1981/82. It must be acknowledged that the true running costs would be more than double those figures as there are many inputs by State Departments for which no charge is made. The gross annual value of the crops which the existing scheme is intended to support is $400 to 450 million. The f.o.b. value of related exports is 25 to 30% of this figure.

Governments in Australia provide varying degrees of services to the ornamental horticultural industries. Whilst in most cases industry would like to see greater involvement, continued pressure could improve the situation.

Conclusion. There are other vegetatively propagated fruit crops and, indeed, plants which are not covered by fvf schemes and in considering development of a scheme for ornamentals, priorities would have to be considered. For example, funds are required for the maintenance of plant genetic resources which need to be balanced against any expansion of the fvf scheme into ornamentals would be favourable received by Governments considering their generally tight financial situation and growing acceptance of the principle that "the user pays." Perhaps an expanded activity in the production of disease-free propagation material of ornamentals seems justified, but the best means of achieving this needs close appraisal. Maybe low cost systems of maintaining and distributing this material, such as is happening in Victoria, is the best way to proceed.

The real questions which need to be answered I think are these:

- What are the threats to the commercial ornamental industries under the present system?
- What would be the benefits of an fvf scheme?
- Is there a real need?
- What is the demand?
- Will the user pay?

MICROPROPAGATION OF GRAPEVINE

K.G.M. SKENE and M. BARLASS

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Abstract. A method is described for the *in vitro* propagation of grapevine (*Vitis vinifera* L.) from fragmented shoot apices, which has the potential of

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Abstract. A method is described for the *in vitro* propagation of grapevine (*Vitis vinifera* L.) from fragmented shoot apices, which has the potential of

producing many thousands of plants from a single apex between one growing season and the next Apical fragments were grown in a liquid culture medium with cytokinin but in the absence of auxin Transfer of the differentiated fragments to the same medium solidified with agar resulted in shoot masses which could be repeatedly subcultured Excised shoots readily initiated roots on a basal medium which, for most cultivars, was supplemented with low levels of auxin Plantlets were successfully transferred to the glasshouse and subsequently to the field The technique has also been used for a range of *Vitis* species and hybrids, and is considered to have promise for the commercial clonal propagation of grapevine

REVIEW OF LITERATURE

Although *in vitro* propagation has mainly been a technique applied to herbaceous species, the number of woody perennials that are now propagated by tissue culture, or offer promise of being multiplied in this way, is steadily increasing (e.g., 15). In the case of grapevine, Galzy (6) first described a technique for the growth *in vitro* of explants bearing terminal or lateral buds. However, her method was not designed specifically to stimulate multiple shoot formation. Limited multiplication of lateral buds has been achieved recently with *Vitis vinifera* 'Sylvaner' (7), and somatic embryos have been induced in *V. vinifera* 'Cabernet Sauvignon' (9) and the hybrid 'Seyval' (8). *In vitro* plantlets have also been produced from cultures of *V. riparia* × *V. rupestris* (5), apparently from embryos (13) Barlass and Skene (1) reported on a method that produced many shoots from a single fragmented apex of *V. vinifera* 'Cabernet Sauvignon', and suggested that it had potential for micropropagation of grapevines. They later extended their findings to other *V. vinifera* cultivars and other *Vitis* species (2,3,4). This paper describes the features of the phenomenon that are relevant to micropropagation.

MATERIALS AND METHODS

Grapevines raised in the glasshouse from hardwood cuttings provided the main source of experimental material. Results were essentially the same from glasshouse and field-grown vines, from vines in growth cabinets, and from vines raised *in vitro* from tip cuttings. Most experiments were carried out on *Vitis vinifera* 'Cabernet Sauvignon', although later work included other cultivars of *V. vinifera*, and several *Vitis* species and hybrids (Table 1). All of these cultivars are now being routinely cultured *in vitro* in our laboratory by the methods described below.

Shoot tips about 1 cm long were surface-sterilised for 15 min in a 5% w/v filtered solution of calcium hypochlorite containing 0.01% v/v Tween-20 and rinsed three times in sterile distilled water. Apices approximately 1 mm in length were excised under aseptic conditions and cut into several pieces on dry pre-sterilised 50 mm plastic dishes. These fragments were further teased

Table 1. Grapevine cultivars to which the fragmented shoot apex procedure has been applied

Cultivar	Parentage
Cabernet Sauvignon	*Vitis vinifera*
Cabernet Franc	*V vinifera*
Sultana (Syn Thompson Seedless)	*V vinifera*
Muscat Gordo Blanco (Syn Muscat of Alexandria)	*V vinifera*
Doradillo	*V vinifera*
Concord	*V. labrusca*
Ramsey (Synonym Salt Creek)	*V champini*
Dog Ridge	*V champini*
Rupestris St George (Syn Rupestris du Lot)	*V rupestris*
R-99	*V rupestris* x *V berlandieri*
1613	*V longii* x *[V vinifera* x *(V riparia* x *V labrusca)]*
Harmony	Dog Ridge x 1613

apart after addition of 5 ml of the basal culture medium of Murashige and Skoog (MS) (11) supplemented with 2 mg/l benzyladenine. In additional experiments, the basal culture medium was supplemented with varying concentrations of benzyladenine (BA, 1 to 5 mg/l), as well as kinetin (K, 2mg/l), zeatin (Z, 1mg/l), α-naphthaleneacetic acid (NAA, 1mg/l), and 2,4-dichlorophenoxyacetic acid (2,4-D, 1mg/l), alone or in combination. A comparison was also made between growth in liquid and solid media. Petri dishes were sealed with Parafilm and incubated in a temperature-controlled room maintained at 27°C during the light period (15 h) and 20°C during the dark period (9 h). Light was provided by cool white fluorescent tubes giving approx. 3,000 lux at the culture level. Early experiments on the effects of constant darkness were not continued, due to the unsatisfactory growth of the apical fragments under these conditions.

The leaf-like structures that developed during culture in liquid medium (see 1) were transferred to the same medium solidified with agar (6 g/l) between 2 and 4 weeks after the start of culture. Shoots, which eventually developed from swellings at the basal ends of the leaf-like structures after transfer to solid medium (1,2,3,4), were individually excised and transferred to rooting medium. The rooting medium, contained in autoclaved 80 x 25mm screw-capped clear polycarbonate tubes, consisted of either hormone-free White's medium (14— containing iron in the chelated form or basal MS medium (11) at half strength supplemented with 0.1 mg/l NAA. Both media contained 6 g/l agar.

Rooted plantlets (6 to 8 cm in height) were removed from the agar medium, and after washing the roots in distilled water, the plantlets were transferred to Jiffy 7 peat blocks (Jiffy Products Ltd., Grorud, Norway) and maintained, continuously moist, in

glass tanks in the temperature-controlled light room for approximately 9 days. The lid was then removed from the tank. After a further 2 weeks plants were placed in potting mix (initally a John Innes/perlite mixture, but more recently peat and sand in equal proportions) and transferred to the glasshouse.

RESULT AND DISCUSSION

Unless specified, the results refer to 'Cabernet Sauvignon'. Apical fragments began to grow within the first few days of

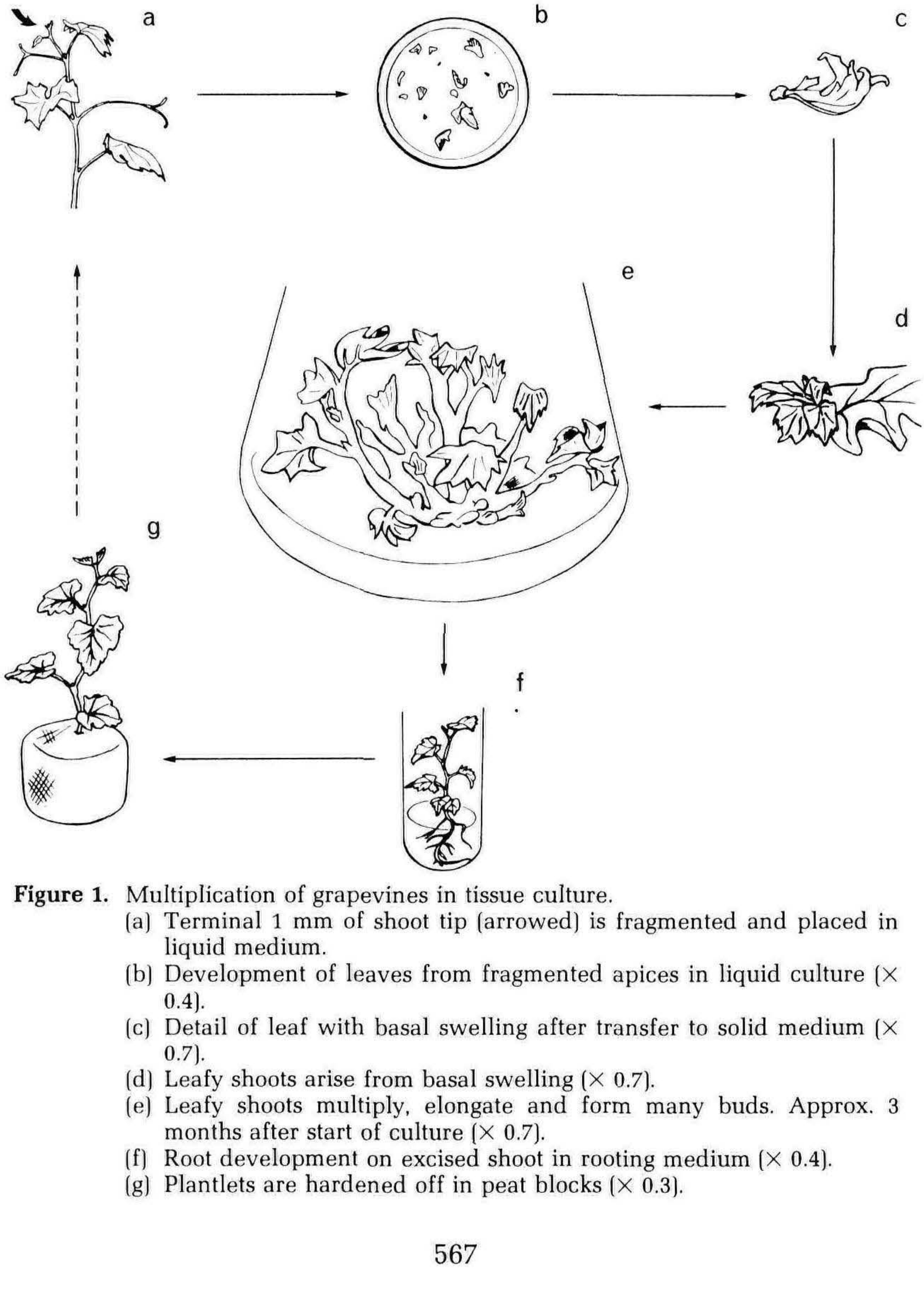

Figure 1. Multiplication of grapevines in tissue culture.
(a) Terminal 1 mm of shoot tip (arrowed) is fragmented and placed in liquid medium.
(b) Development of leaves from fragmented apices in liquid culture (× 0.4).
(c) Detail of leaf with basal swelling after transfer to solid medium (× 0.7).
(d) Leafy shoots arise from basal swelling (× 0.7).
(e) Leafy shoots multiply, elongate and form many buds. Approx. 3 months after start of culture (× 0.7).
(f) Root development on excised shoot in rooting medium (× 0.4).
(g) Plantlets are hardened off in peat blocks (× 0.3).

culture in liquid medium (MS + BA 2 mg/l), and by the third week up to 20 leaf-like structures, some 1 cm long, were evident in each dish (Figure 1b). These structures were, in fact, leaves. They have been shown to originate from pieces of leaf primordium (3), and heareafter will be referred to as *in vitro*-grown leaves. Fragmented apices cultured on solid media grew more slowly and erratically than did comparable material cultured in liquid. In later experiments, the initial stages of culture were always carried out in liquid. However, after the 2nd to 4th weeks, it was necessary to transfer *in vitro*-grown leaves to solid medium to stimulate subsequent development, the actual time of transfer depending on the cultivar and its rate of growth.

After transfer to solid medium, the *in vitro*-grown leaves, each with a basal swelling of the central vein (Figure 1c), increased to about 30 mm in length. During the next 4 weeks, leafy shoots began to appear from the basal sweling (Figure 1d). Excision of this area from the *in vitro*-grown leaves, followed by subdivision and subculturing to the same medium, resulted in a prolific formation of buds. There then followed a continuous process of bud multiplication and expansion to produce many elongating shoots in each culture (Figure 1e). These shoots could be repeatedly multiplied and subcultured to achieve the desired numbers.

The addition of various growth regulators to liquid media containing fragmented apices of either 'Cabernet Sauvignon' or 'Sultana' confirmed that 2 mg/l BA, without auxin, was optimal for the initial growth of apical fragments, and also for their subsequent ability to proliferate shoots when transferred to solid medium (4). Other cytokinins and auxins elicited only short-lived responses. The inclusion of NAA in the solid medium containing BA favored callus production rather than continued leaf growth and shoot proliferation.

Excised shoots from 'Cabernet Sauvignon' cultures rooted readily on hormone-free White's medium, with roots first appearing after about one week. All other cultivars, except 'Cabernet Franc', required auxin to stimulate root formation (0.1 mg/l NAA). Once root initiation occurred, shoots were transferred to hormone-free medium to prevent root distortion. Approximately 2 weeks after the onset of root initiation, plantlets showing active root and shoot elongation were transferred to peat blocks, and hardened-off, as described in Materials and Methods, for approximately 3 weeks, before putting into pots in the glasshouse. Losses during this critical early period out of culture were quite low.

So far, this technique has been attempted with a range of grapevine cultivars, including several major *Vitis* species (2, 4;

Table 1). Although there were minor differences in response, all material basically exhibited the same pattern of behaviour, except that *V. rupestris* and its hybrids gave only limited bud proliferation. It is not surprising that optimal cultural requirements differ among *Vitis* species, and the media may require some modification as occasion demands.

The growth habit of *in vitro*-grown shoots resembled seedlings with respect to the absence of tendrils, spiral phyllotaxy, and leaves lacking lateral sinuses. However, this apparent juvenility is a common feature of *in vitro* grapevine cultures (e.g., 12), and mature characteristics quickly appeared on transfer to the glasshouse (viz., production of tendrils, alternate phyllotaxy and characteristic leaf shape). Moreover, these same plants produced fruitful buds during their first season in the field, whereas seedlings would usually take several seasons to flower.

It can be calculated that the proliferating grape cultures have the potential of producing several thousand plants from a single shoot tip between one growing season and the next. This rapid multiplication would be of particular advantage when plants are in short supply as, for example, when new or introduced cultivars first become available for release. We consider that micropropagation is capable of producing many more plants in a given time from limited stocks than even methods such as the striking of green cuttings under mist.

Finally, there is the question of whether the resulting plants are true-to-type. Genetic instability is a problem more usually associated with long-term culture of callus (10), and as the grapevine system described here allows very little callus formation, it is felt that plantlet variation is likely to be minimal, particularly if individual cultures are not maintained for extended periods. One hundred 'Cabernet Sauvignon' vines propagated through tissue culture were planted in the Mildura region during December, 1979, as a first step towards answering this question. Outwardly the vines appear true-to-type, but further comment at this early stage would be premature. They will be observed during the next few years to assess whether any changes occurred during tissue culture.

Acknowledgment. Ms L J Kramm provided skillful technical assistance

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PLANT BREEDING WITH A WOODY PERENNIAL — THE GRAPEVINE

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HISTORY

The idea of breeding grape cultivars specifically for Australia is almost as old as Australian viticulture itself. The Macarthurs, more famous for their activities with sheep, also grew grapes and believed that they should raise vines from seed to allow selection of types suited to local conditions. Busby (3) records that William Macarthur had 250 such seedlings, out of a much larger number raised from seed in 1824, under trial. None of these appear to have survived and this may be because they were not the result of deliberate crosses but raised from open-pollinated

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seed. We now know that most of this would be self pollinated and the seedlings would lose much of the heterotic vigour of the parent. Busby himself (2,3) advocated a deliberate breeding program as the surest means of obtaining grapes suitable to the climate.

Busby went to Europe and made as complete a collection of grape cultivars as he could to establish in Australia with the intention of systematically testing them (4). Unfortunately he left Australia soon afterwards and this testing was never done. The collection was allowed to degenerate into confusion which was further confounded when collections were established from it in Victoria and South Australia. Ultimately the whole effort appeared to be dissipated and lost. In fact, more of these cultivars survive than is generally realised and our Division is trying to collect them from old vineyards before they are finally lost. Having left Europe before grafting was needed they are often in a good state of freedom from virus diseases.

In any case it was found that some cultivars would grow well in suitable localities in Australia and that they would produce wines true to cultivar, a fact very much counter to the doctrine prevailing in Europe at that time. This may be one reason why Busby's recommendation of a deliberate breeding program was not followed up.

The first European grape breeding program was started at about this time with a clarity of definition of objective and plan of action which could hardly be improved upon now. Louis Bouschet considered that a cultivar which would impart more colour to the red wines of Mediterranean France was needed. He began in 1824 by collecting from other areas of France cultivars which gave the wines of most colour. When he found that none of them would grow very well in his area he chose the one he thought gave the most colour, 'Teinturier du Cher' and, in 1828, crossed it with some of the local vigorous and high yielding cultivars. From the cross with 'Aramon' came 'Petit Bouschet', a little of which is still grown, but which still did not have the vigour and yield desired. His son Henri Bouschet carried on the work by crossing 'Petit Bouschet' with the local cultivars and, from the cross with 'Grenache', came 'Alicante Bouschet' which is still a very successful cultivar. Since then there have been many breeding efforts in many countries. Sometimes the only objective seems to have been the breeder's wish to produce a cultivar to name after his patron, his family or friends, or even himself. This has resulted in the world's cultivar collections being cluttered up with cultivars of no observable value and is not a practice to be recommended. On the other hand, some very successful cultivars have been produced by people who knew what they were looking for and, in Germany, for example, the

stage has now been reached where more than half the wine is produced from deliberately bred cultivars. At one stage about ⅓ of French vineyards was planted with disease resistant hybrids and a few of the best of these are still extensively grown.

The reports of the Queensland Acclimitization Society from 1899 to 1910 contain a harrowing serial of what may have been the first Australian grape breeding program This was plagued by the necessity to shift the plantings on several occasions at short notice with consequent heavy losses of vines and terminated by financial difficulties with the wholesale retrenchment of staff. However, in its heyday it claimed one record, a seedling which bore ripe fruit only 14 months after the seed had been sown. This shows the advantage of carrying out such a program in a climate encouraging vigorous growth and development. There is little doubt that it had the potential to produce a backyard table grape suitable for the humid coastal areas of Queensland.

The first deliberately bred cultivar to be named in Australia was a table grape, 'Nyora', introduced by the New South Wales, Department of Agriculture in 1963. The breeder, Mr. W.J. Poggendorf, who was primarily a cereal breeder, made the cross at Yanco in 1937. There have been a few other small breeding programs which did not continue long enough to give rise to any new cultivars, although a few selections from these are still being maintained. Breeding at CSIRO Division of Horticultural Research began in 1964 and has continued at varying intensity every since.

TECHNIQUES

Grape flowers come in three sexual types. Wild vines are dioecious, with male and female flowers borne separately on different vines, and some cultivated vines have female flowers. The third type, hermaphrodite, appears to be a sport which can be maintained only under cultivation. There is no mechanism for discouraging self pollination, which may explain why it does not establish in the wild. Male is dominant to hermaphrodite and both of these are dominant to female. Male flowers can be induced to produce pistils which will set seed by treatment with a suitable cytokinin (6), so it is possible to make crosses in all combinations except female × female or seedless female × any type. In practice, because hermaphrodite cultivars set fruit most reliably, the combinations most often used are hermaphrodite × hermaphrodite and female × hermaphrodite. Homozygous hermaphrodite cultivars are advantageous, particularly in the second case; well known cultivars with this character include Riesling, Chardonnay, and Muscat Hamburg.

Breeding techniques for grapes have been revised by Einset and Pratt (5). At Merbein we usually collect pollen on a glass

plate from attached inflorescences, emasculate with pointed forceps and pollinate with a camel hair brush. Brown paper bags folded over and secured with paper clips are used to exclude unwanted pollen. Grape seeds need to undergo a period of cold, from about 2 to 12 weeks according to cultivar, before they will germinate. We usually plant the seed as soon as the fruit is harvested and keep the seed boxes at about 2°C but it is also possible to store the fruit at this temperature and then extract and plant the seed. The boxes are transferred to a glasshouse held to about 25 to 30°C by day and 15 to 20°C by night for germination. To maintain seedling growth during winter we give a light break of one hour in the middle of the night. We leave seedlings in the boxes and plant directly in the field in late spring or early summer 1m apart in rows 2.5m apart. Seedlings which are likely to be of any value should produce enough fruit for evaluation in their 3rd, 4th and 5th years.

OBJECTIVES

Australia usually ranks only about 16th among the countries of the world as a producer of wine grapes but ranks about 4th as a producer of grapes for drying. This usually means that grape production is split more or less equally between winemaking and drying, and so grape breeding in Australia should consider both end uses.

Nearly ¾ of the grapes used for wine in New South Wales, Victoria, and South Australia come from the irrigation areas of the Murrumbidgee and Murray Valleys and most in Western Australia from areas near Perth. The climate in these areas more nearly resembles that of north Africa than that of Europe.

Most of our wine grapes come from Europe, particularly from France. These cultivars are not necessarily suited to the hot areas. They ripen while the weather is still very hot and are likely to lack both acid and flavour compounds. A few cultivars brought in recently from southern Italy are better in this respect but they still have some disadvantages.

We are therefore trying to breed wine grape cultivars that ripen later in the season and maintain a good acidity as they ripen

In contrast to wine grape cultivars, ripening in the hot weather is desirable in the case of drying grapes, to give suitable conditions for natural drying. The main improvement required over existing cultivars is an ability to withstand the effect of rain on grapes that are almost ready to harvest. Only Greece, among the major producers of dried grapes, has such uncertain weather at harvest time as Australia.

Although the requirements for new drying and wine grapes

for our hot areas would appear to be so different, there is so much variation among seedlings raised from the same parents that it is possible to make selections for both purposes. Thus we felt justified in using 'Sultana' as one parent in many of our early crosses. It is Australia's leading drying grape and might give offspring with seedless grapes, a very desirable feature for a drying cultivar. In many seasons it is also Australia's leading wine grape in quantity crushed, and has desirable characteristics, such as good acidity, which it could contribute to new wine grape cultivars. Because most 'Sultana' offspring have seeded fruit and are not suited as drying cultivars this is an important consideration.

The range of variation available for selection cuts across ideas about the best areas for producing quality wines. There may be a special relationship between area and cultivars, and with different cultivars it may be possible to produce quality wines in apparently unpromising areas. Because poorly adapted cultivars produce grapes lacking acid and flavour in the hotter parts of the Murray Valley it is often assumed that this is a characteristic of the area. However, seedlings raised at Merbein indicate that this is not so. Some have such a long growing season that they do not ripen their fruit and others have fruit with enough sugar but so much acid that their wines are undrinkable by themselves. The new Merbein cultivar, Tarrango, a red wine grape named in 1975, gives wines in the Murray Valley similar in composition to those from French cultivars grown in much cooler areas.

A more recent breeding objective is the incorporation of resistance to fungal diseases. As well as reducing the amount of energy required for grape production, this is a more environmentally acceptable method of disease control, a point which could be of some significance when so many consumers visit wineries and their vineyards. Disease resistant cultivars could be particularly important in areas such as the Hunter Valley where the summer rainfall and humidity are favourable to fungal development. The French hybrids, produced by private breeders in France between about 1880 and 1950 using American species, such as *Vitis rupestris*, in crosses with cultivated cultivars, are a good source of resistance. With the long history of breeding behind them some of the more recent hybrids show an acceptable combination of quality and resistance. Some of them give seedless offspring when crossed with seedless cultivars so we are using them for breeding both drying and wine cultivars.

Of more than 40,000 seedlings so far raised in our programme, evaluation of 30,000 seedlings is well advanced. To date, four cultivars have been named (1) and three are likely to be in the near future.

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METHODS USED IN AVOCADO BREEDING

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Abstract. A hybridization programme involving controlled hand pollinations has been developed for the avocado The floral mechanism is very temperature-sensitive and crosses are carried out in a temperature-controlled glasshouse to ensure suitable conditions for pollen tube growth and fruit set Grafting techniques are used to ensure synchronous flowering of cultivars which otherwise would not flower at the same time Because the majority of pollinated fruitlets abscise an embryo-culture method is under development to increase the numbers of progeny obtained from each cross Progeny are topworked onto large stumps for a rapid assessment and are also planted out on virus-tested seedling stocks

The avocado (*Persea americana* Mill.) is a relatively new crop to Australia and the industry is based largely on cultivars developed overseas. These cultivars do not entirely satisfy the requirements of the Australian industry and are not suitable for the wide range of climates present in Australia. There is demand for year-round supplies of fruit and there are also problems with existing cultivars due to the biennial bearing habit. Other scion characteristics of interest include time of flowering, fruit colour, shape and size, skin thickness, seed size, and fresh flavour, quality and oil content. Desirable rootstock characteristics include salinity tolerance, resistance to the root rot fungus *Phytophthora cinnamomi*, and a dwarfing habit.

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There are three methods of tree crop improvement. The first is plant introduction where cultivars developed overseas are introduced and tested under Australian conditions. The second method of improvement is known as field selection. Seedlings from open-pollinated trees are assessed for horticultural characteristics. This method may yield a new superior cultivar but nothing is learned of the inheritance of the desirable characteristics as the female but not the male parent is known. The third method of improvement is controlled hand pollination followed by selection of the progeny for desirable characteristics. Using this method the identify of both parents is known and a study of the genetics of the crop can be commenced. This latter approach will be described further.

Woody perennial tree crops are particularly difficult to breed for three reasons. Most species have outbreeding mechanisms, which must be understood before crossing can be commenced; they have low fruit to flower ratios, and all have long generation times. Our research aims to overcome these problems.

The avocado has an outbreeding mechanism called dichogamy. Each flower opens twice. On first opening the flower is in the female stage with the pistil exposed, the stamens reflexed against the petals and the anthers not yet dehisced to release the pollen. In this stage pollination of the flower results in fertilisation and fruit set. The flower then closes completely and re-opens the following day in the male stage. The pistil is now obscured by the stamens whose filaments have extended and anthers dehisced to release the pollen. In this stage the flower can no longer be fertilised. The flower then closes again and does not re-open. Complementary flowering types exist so that pollen transfer can occur. In type A cultivars, e.g. 'Hass', the flower opens in the female stage in the morning. It closes toward the middle of the day and re-opens in the male stage during the afternoon of the following day. In type B cultivars, e.g. 'Fuerte', the flower opens in the female stage in the afternoon, closes overnight and re-opens in the male stage the following morning. The overall effect of this is that open flowers on a type A tree are female in the morning and male in the afternoon and *vice versa* for a type B tree. Pollen transfer can thus occur between the two flowering types. In the orchard the pollen is transferred by insects

Our research using controlled environment growth cabinets has shown that this mechanism is very temperature sensitive. At a daytime temperature of 25°C the floral cycle is normal and pollination results in pollen tube growth and embryo development. At daytime temperatures above 30°C there is excessive shedding of flowers and young fruits and pollen tube growth may be abnormal Below 20°C the floral cycle is disrupted and the

female stage may be omitted as in the Fuerte cultivars or the male stage may open during the night as in the Hass.

As a result of these findings our crossing programme is carried out under controlled conditions. The potted plants are housed in an insect-free glasshouse with a daytime temperature of around 25°C. Hand pollinations are carried out by removing dehisced anthers from male stage flowers and gently transferring the pollen by direct contact to the stigma of the female stage flower. Removal of the anthers is unnecessary as avocado pollen does not become airborne. Pollinated flowers are labelled with coloured cotton and a few flowers are pollinated each day over the flowering period.

One problem is that different cultivars may flower at different times. This problem has been overcome using a grafting technique. Floral budwood is collected from trees in the orchard and is stored for up to 4 months at 4°C. The budwood can then be bottle-grafted when required to mature stock plants which have been previously disbudded and topped to produce a build up of carbohydrate. These grafts will flower after a few weeks and, because of the maturity of the stock and the large graft area, may carry fruit to maturity when pollinated. Thus early- and late-flowering cultivars can be manipulated to flower synchronously for crossing.

One of the major problems in breeding woody perennial tree crops is the low fruit to flower ratio. The problem is particularly acute with the subtropical crops such as avocado where millions of flowers may be produced but a good crop is measured in thousands of fruit. This means that most of the hand-pollinated fruit will be shed before fruit and therefore seed maturity. An *in vitro* culture method is under development so that the shed embryos can be saved. The embryo culture medium stimulates the production of shoots which are then micrografted to stock plants.

The final problem in breeding woody perennials is the long generation time. A seedling avocado tree may take over 10 years to flower and fruit. This problem may be partly overcome by grafting onto a rootstock of a large tree which has been topped (pollarded). The progeny are also planted out on virus-tested seedling stocks.

The development of breeding methods for avocado was commenced in 1975 and further work is required to perfect the techniques. We hope that this approach will produce new avocado cultivars better suited to Australian conditions and also lead to some understanding of the genetics of the crop so that future breeding programmes can be scientifically based. The experience

gained in developing methods for avocado breeding will be applied to other tree crop species.

RAPID INDEXING OF SUNBLOTCH VIROID IN AVOCADOS AND OF EXOCORTIS VIROID IN CITRUS

ROBERT H. SYMONS

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Abstract. It appears feasible to replace the time-consuming biological indexing of the sunblotch disease of avocados and possibly also of the exocortis disease of citrus by a more rapid method which is highly specific and can be completed in several days This new method involves the sensitive detection of the avocado sunblotch viroid and the citrus exocortis viroid in partially purified nucleic extracts of candidate trees by a technique known as hybridization analysis Details of this new method are given together with a summary of the results so far obtained

INTRODUCTION

Viroids are the smallest pathogenic agents known and consist of single-strand, circular RNA molecules which are only 300-400 residues long (3). Unlike normal plant viruses, viroids are not protected by a protein coat and are spoken of as naked molecules. They infect a wide variety of plants and, in many, produce severe disease symptoms. Of the eight viroids so far described, at least five are of considerable agricultural importance; these are potato spindle tuber viroid, hop stunt viroid, cadang-cadang viroid of coconuts, avocado sunblotch viroid, and citrus exocortis viroid. Only the latter two are present in Australia.

A characteristic property of viroids is their slow rate of growth and the long time taken for symptom development as compared with many plant viruses. Indexing for the presence of viroids by symptom development in suitable indicator plants can take a minimum of two to three weeks for such viroids as potato spindle tuber viroid or two years and more for avocado sunblotch viroid, and especially cadang-cadang viroid. Hence, the development of more rapid procedures for the indexing of a least some viroid diseases is most important. This paper summarizes our results so far on the development and use of a very specific and rapid indexing procedure for avocado sunblotch viroid and citrus exocortis viroid.

AVOCADO SUNBLOTCH VIROID AND CITRUS EXOCORTIS VIROID

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AVOCADO SUNBLOTCH VIROID AND CITRUS EXOCORTIS VIROID

Avocado sunblotch, a serious disease affecting avocados (*Persea americana Mill*), was first described in California nearly

50 years ago and more recently in Australia (9). Its infectious nature was established by seed transmission, by grafting and more recently by pollen transmission (4). Indexing for the presence of sunblotch disease has been carried out by graft transmission to suitable indicator avocado seedlings with a requirement of 15 avocado seedlings for each avocado test sample and maintenance of these plants for a minimum of two years (1). This procedure obviously places severe limits on glasshouse space and restricts the number of avocado samples that can be indexed at any one time. Also, the long time taken for the assay can cause serious delays in the release of material for rootstocks and for grafting.

The purification and characterization of a viroid (avocado sunblotch viroid, ASBV) from sunblotch infected avocados (2,6,8) has allowed the development of a new rapid indexing procedure which is described below. Although ASBV has not yet been shown to be the causative agent of sunblotch disease, it is always found in infected but not in healthy avocados, and all evidence indicates that it is an essential component of the disease (see below).

Exocortis disease of citrus is normally indexed using Etrog citron *(Citrus medica* 'Etrog') or *Gynura aurantiaca.* Although the citrus industry is well established and there is a reasonable supply of CEV-indexed trees for use as a source of seed for rootstock or for budwood for scions, it is considered that there is still a need for rapid indexing of CEV (R. van Velsen, personal communication). This could possibly become more important in the future with the potential widespread use of the so-called dwarfing principle of citrus which is believed to be a strain of CEV

PRINCIPLE OF MOLECULAR HYBRIDIZATION ANALYSIS FOR INDEXING OF VIROIDS

Basically, the principle and practice of the use of hybridization analysis for the indexing of viroids are relatively simple and straightforward (Figure 1). The first requirement is for a rigorously purified viroid and we have developed methods which allow the facile purification of ASBV, CEV and chrysanthemum stunt viroid (7). Only 1 to 2 μg of this viroid is required to produce highly radioactive (^{32}P) complementary DNA (cDNA) to the viroid (6). This ^{32}P-cDNA probe is synthesized enzymatically and its nucleotide sequence is an exact complementary copy of the nucleotide sequence of the viroid. Under optimal experimental conditions of ionic strength and temperature, which are determined empirically, the single-strand ^{32}P-cDNA probe will combine (hybridize) with the single-strand viroid RNA such that the nucleotide residues in the DNA are exactly base-paired with the com-

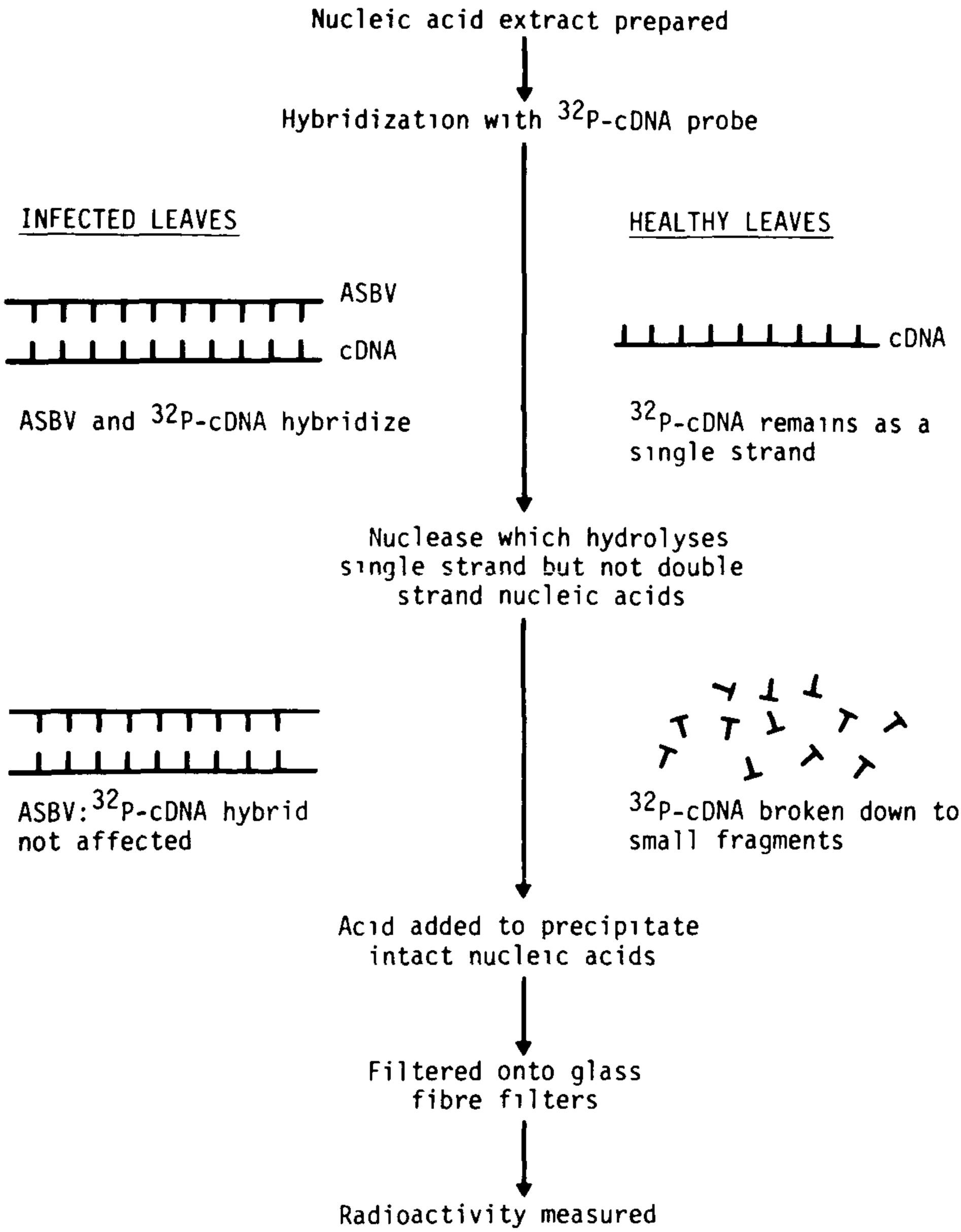

Figure 1. Summary of the procedure for the hybridization analysis of avocado sunblotch viroid in partially purified nucleic acid extracts of avocado leaves

plementary nucleotide residues in the RNA; i.e., the A, C, G and T residues in the cDNA will base-pair with the U, G, C and A residues in the RNA, respectively.

The ^{32}P-cDNA probe is then hybridized under defined conditions with the partially purified extract of RNA from the candidate tree, usually for three days. During this time, the ^{32}P-cDNA probe will hybridize with any viroid RNA sequences present in the extract to form a double-strand DNA:RNA hybrid; if there is no viroid present, then no double-strand hybrids will form as the hybridization reaction is extremely specific. The reaction mixture is then treated with an enzyme (nuclease) which specifically hydrolyses single-strand, but not double-strand, nucleic acid molecules. Hence, the double-strand cDNA:RNA hybrid remains intact while any ^{32}P-cDNA which has not hybridized is digested to very small fragments. The double-strand ^{32}P-cDNA:RNA hybrid molecules can be precipitated by the addition of strong acid and are collected by filtration on to a fine filter of glass fibres; only large fragments are precipitated in this way so that all small ^{32}P-cDNA fragments pass through the filter. The amount of radioactivity retained on the filter is then determined in a radioactive counter. If no radioactivity is found on the filter, then there are no viroid sequences present in the nucleic acid extract (see comments below on the lower level of sensitivity). If a high proportion (over 50%) of the radioactivity initially added in the ^{32}P-cDNAprobe is found on the filter, then viroid sequences are present in the nucleic acid extract.

In summary, therefore, a ^{32}P-cDNA probe is hybridized with a partially purified nucleic acid extract of the candidate tree and the proportion of the ^{32}P-cDNA which is converted to a nuclease resistant, acid-precipitable form is determined. If the leaf extraction is done on Monday, the hybridization reaction can be set up on Tuesday and assayed on Friday; the whole procedure can therefore be completed in five days.

APPLICATION OF THE HYBRIDIZATION ANALYSIS FOR INDEXING OF SUNBLOTCH VIROID

Since ASBV has yet to be shown to be the causative agent of sunblotch disease, it is important to show that ASBV is always present in trees indexed biologically as positive for sunblotch and absent in all trees indexed biologically as negative. Application of the hybridization assay to partially purified nucleic acid extracts of 12 avocado isolates indexed as positive for sunblotch showed that all isolates were also positive for ASBV by the hybridization assay. The results therefore show a 100% correlation between sunblotch disease and the presence of ASBV by the cDNA hybridization analysis.

By appropriate variation of the hybridization assay (6,7) it is possible to determine the concentration of ASBV in the partially purified nucleic acid extracts. In four separate avocado isolates, the concentration of ASBV varied 10,000-fold, from 0.2% to 2×10^{-5}% by weight. At the higher concentrations of ASBV (above 2×10^{-2}% by weight), the presence of the viroid in the partially purified nucleic acid extracts can be detected visually by electrophoresis of samples of the nucleic acid extracts on polyacrylamide gels followed by staining of the gels with dyes to show up the nucleic acid bands. This is certainly simpler and faster than the cDNA hybridization analysis, but this approach cannot be used for the routine indexing of sunblotch because of its low sensitivity.

The lower limit to the detection of ASBV sequences in partially purified nucleic acid extracts by the cDNA hybridization analysis is about 1×10^{-5}% by weight. Although it is technically difficult to further lower the sensitivity more than several-fold using the method described above, it is hoped that future work (see below) will simplify the overall procedure and increase the sensitivity at least 10-fold. Until many more estimates are made of the level of ASBV in sunblotch infected avocados, it will not be possible to determine the lowest level of ASBV that can produce the characteristic sunblotch symptoms.

APPLICATION OF THE HYBRIDIZATION ANALYSIS FOR INDEXING OF CITRUS EXOCORTIS VIROID

We have so far only carried out very preliminary work in this area. It has been possible to purify CEV, to prepare ^{32}P-cDNA to it and to use it in hybridization assays. However, we have not done routine indexing on a number of isolates nor have we determined the concentration of CEV in partially purified extracts of citrus isolates infected with CEV. However, all evidence so far indicates that we will be able to use the cDNA hybridization analysis for indexing of CEV in the same way as we have done for ASBV.

FUTURE DEVELOPMENTS

The method used so far for the preparation of the ^{32}P-cDNA probe for ASBV only provides low yields of the product. If much larger quantities of the cDNA probe can be prepared, then it becomes feasible to use a higher concentration of the cDNA probe for the hybridization assay in a way which would increase the sensitivity of the assay about 10-fold. Our future approach in this area is to make use of recombinant DNA technology to clone viroid sequences in the form of DNA in bacteria and this should allow the production of large quantities of the cDNA probe. It is

envisaged that a central laboratory could then be responsible for the regular preparation of the radioactive probe for use by regional laboratories for the routine indexing of sunblotch and exocortis diseases.

ACKNOWLEDGEMENTS

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LIBRARY AND INFORMATION SERVICES FOR PLANT PROPAGATORS

ROSEMARY A. WREN
CSIRO Division of Horticultural Research, Merbein, Victoria

In the course of their occupations may people, particularly those who are self-employed or who are associated with small businesses, experience a need for information or technical expertise which they are unable to readily satisfy. Scientific and technical information exists today in greater quantity than ever before, and the store grows rapidly. However, the very mass of available literature can create added difficulties in locating and

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acquiring the particular piece of information required.

Libraries as avenues of information. Library services at local, state and national government level are one of the most important — and often one of the most overlooked — avenues of assistance open to the private citizen seeking information. Some I.P.P.S. members are connected with institutions or bodies which maintain research libraries, so that they have access to library and information services supportive of their needs. For those without direct access to such services, the first point of contact in seeking information will usually be a municipal or state library. Australia has a highly developed inter-library loan system, and a local public library has resources far beyond that of its own collections which can be tapped to obtain needed books or documents. Supporting the services of municipal libraries within each state are the State Libraries, funded by their respective governments to acquire, maintain, and make available to residents of the state, books, periodicals, and other library-type materials.

Services offered by the State Libraries do vary among states but, in general terms, they all maintain readers' services, reference or research departments whose function it is to deal with enquiries and to assist the enquirer to procure the documents containing his needed information. Behind the State Libraries in the government funded public sphere stands the National Library of Australia, located in Canberra but extending its services across the Commonwealth. The National Library houses three specialist libraries: the Australian National Social Sciences Library, the Australian National Humanities Library, and the one of the most concern to plant propagators, the Australian National Scientific and Technological Library, or ANSTEL. ANSTEL operates a national lending service which states its policy as being "to ensure the prompt supply of any known scientific or technical document to any organization requesting it. . . . Document means book, journal article, technical report, conference paper, thesis, standard, patent, or any other form of library material or copy thereof . . ." The term 'organization' includes other libraries, of course, and it will almost always be through other libraries that the services and collections are made available to the individual enquirer.

Locating information. The phrase "known scientific or technical document" opens up a rather more complex problem than that of actually obtaining a document once its existence is known. For very often the enquirer does not know which documents, indeed if any, contain the information he wants. This is particularly the case if it is new or recent information which is sought. Knowledge or expertise which has become widely known or established is fairly readily found in textbooks, and these can usually be purchased or acquired on loan from libraries without

much difficulty. But the latest information or technology is usually to be found in non-book materials of the type mentioned in the ANSTEL statement. Identifying the existence of this literature can be a problem. Information on techniques and scientific data applicable to plant propagation may be found in two or three specialist periodicals, and in a rather greater number of periodicals devoted to the nursery trade industry generally. But it is also scattered over a very large number of other periodicals non-specific to plant propagation. How *is* this information to be retrieved? Again, the answer is through libraries. As mentioned already, the readers' services or reference departments of State Libraries or large municipal and regional libraries, provide a range of services to members of the public without occupational access to private library services. Services offered by State Libraries include literature searches and the preparation of bibliographies on particular subjects, as well as provision of the actual documents.

It may be of interest to the library user to know something of the methods by which libraries and information services do identify and locate information from the mass of scientific and technical literature in existence. Traditionally, articles or documents relevant to an enquiry have been identified through publications often confined to quite a narrow subject field such as horticulture or plant breeding, or their scope may be wider, to take in the whole of agriculture, or biology, or chemistry. Whether wide or narrow in subject coverage, an abstracting journal attempts to provide abstracts or summaries of all articles or papers, and sometimes other kinds of documents such as patents or technical reports, recently published and which fall within the stated scope of the abstracting journal. As well as a summary, the author, title and bibliographic details of the original article are also given. Indexing journals fulfill much the same function as abstracting journals, except that only the bibliographic citation is given, and not an abstract also. One would thus consult "Horticultural Abstracts" to obtain details of articles on grapevine propagation, or "Bibliography of Agriculture" to trace literature on the culture of glasshouse crops in polythene bags.

Computerised searching. Conventional manual methods of searching the scientific and technical literature for information on particular topics have, however, been revolutionised in recent years by the application of computer technology to the storage and retrieval of information. Machine-readable bibliographic data bases have been set up to record the existence of information, and these can be searched by computers located in the United States or elsewhere under instruction from librarians or information specialists within Australia having access to a suitable computer terminal.

Some, although not all, of these computerised data bases correspond to the familiar abstracting or indexing journals. A number of data bases have been constructed within Australia, and are available for on-line computer searching as well as in a microfiche or printed copy format. These include the 'Australian Science and Technology Index' which covers all scientific and technical serial literature published within Australia, and 'CSIRO Index', which indexes all work published by CSIRO scientists. Most of the really large data bases however originate from the United States. They are accessible to us for on-line searching through Telecom's international data transmission services, MIDAS, which enables computer terminals in Australia to communicate interactively with the computers of the U.S.-based information services such as Lockheed's DIALOG or Systems Development Corporation's ORBIT, at an hourly communications charge levied by Telecom at $A12 per hour.

Citations of articles on a particular topic are retrieved by selecting an appropriate data base and expressing the search question as a number of concepts or terms in defined relationships. Each command or instruction is entered on a terminal keyboard and then transmitted to the computer for processing. The system responds by displaying the results of each command, enabling the searcher to proceed to the next command or to modify the search depending on the results received. A searcher keying in, separately, the truncated terms "almond?" and "propagat?" will obtain a computer response indicating the number of citations retrieved on each of those terms. If a command to combine these two sets using the "and" operator is then given, the searcher will receive a response showing the number of articles dealing with the propagation of almond trees. If there are only a small number of citations the searcher may command that these be immediately displayed or printed on the computer terminal. If necessary, a search may be narrowed by the use of search options additional to subject descriptors, such as author or journal names, publication dates, language of text and so on. If more than a few citations have been retrieved an instruction may be given that the results be printed off-line by the host computer. In this case the printed output is airmailed to the searcher, arriving in Australia within five or six days.

A typical computer search incurs direct costs of between $5 and $20. The cost components are a Telecom charge of 20¢ per minute, an online connect time charge payable to the host system, which varies according to the data base searched, and a charge for each citation printed. This, too, varies according to the data base searched. By charging enquirers only a sufficient amount to recoup the direct costs involved, the CSIRO Information Service located in East Melbourne is enabled to provide

Australian industry and the public with a computer search service in the fields of science and technology, including agriculture. CSIRO also offers computerised current awareness services which can provide an enquirer with a regular listing of up-to-date literature on a particular topic, on greenhouse management, for example, or fruit tree rootstocks.

The information and library services outlined in this paper are an important national resource. They can and should be exploited by the plant propagator who wishes to keep abreast of the latest technology in his field or to enlarge his knowledge of any aspect of plant science.

THE ROLE OF EDUCATION IN GAINING RECOGNITION FOR THE PLANT PROPAGATOR

BRIAN G. PELL

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Department of Agriculture
Wellington Parade, East Melbourne

The first thing we must recognize is that the people we employ in the 1980's must be different from the people we employed in the 1950's or 60's. Even those of us who had advanced training and education, have learnt much of our present expertise by experience, often from the boss. We have had 20, 30, 40 years of experience.

I am impatient. When I employ someone, whether it be a gardener a clark or a lecturer, I don't want to wait 20 years for him to get experience. I want him to be able to do the job NOW. I can hear some of you saying that there is no substitute for experience. Think of the most difficult technique that you can do. How did you learn it? My guess is that for most of you, you may have read about it somewhere and then by trial and error, by a lot of experience, you have mastered the technique. Now looking back, couldn't you teach it to someone else a lot quicker? You could tell him what he needs to know, show him the little short cuts that you can take and the ones you can't. Sure it will take experience — but less than what it took you.

That's what we want from education — to get people to a particular level in a particular type of work in a shorter time and with cost efficiency. Cost efficiency is getting the most training for the least amount of finance, and it is going to be the single most important factor in education and training institutions in 1980.

Whether we like it or not, the two most important factors in the status given by the community to any occupation is the level

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Whether we like it or not, the two most important factors in the status given by the community to any occupation is the level

of training required to enter the industry and the salary paid to those people. The low status accorded those in the nursery industry is a reflection — partly of our own attitude towards both these factors. Neither salary nor training necessarily makes a good nurseryman or plant propagator. However they are factors in attracting the best practitioners into the field and that's what we need — the best people we can get.

In the past there has been a tendency for all horticulturists to be called gardeners, and since gardening is the single most common form of recreation, the community feels anyone can be a gardener. This attitude needs to be counteracted. Within gardening there are specialized areas and propagation is one of the most specialized. With the introduction of tissue culture a new breed of technologists will be required; these people need to be highly trained and have a thorough understanding of many disciplines including pathology, microbiology and plant nutrition.

To gain recognition for the profession of propagation we need to take two very positive steps —

(a) We need to improve our public image

(b) We need to ensure that there is opportunity for adequate training

Firstly let us consider how to improve the public image of those in this field of employment. Each of us needs to have a great deal of confidence in what we do and then we must take every opportunity to let the public know what we do and that we are skilled in our tasks. How often do we hear how skilled airline pilots are? They continually use this argument to justify their salaries.

We also need to impress upon those we employ how important is a good public image. In addition to individual promotion there must be a real effort from the industry — from groups such as the I.P.P.S. How often does this Society make a news release on a new technique? It is these developments that are making a wider range of plants available to the public. This is information that the public wants to know about and it is only societies such as this that can provide the information to the news media.

You, the producers, must be prepared to put money into promotion. It is not just a question of greater sales, it is also important that the public understands what you do, how you do it, and why you do it. The public must be convinced that propagation is a profession.

The second area is the area of training. Since I will be referring to Victoria — I should outline what is available here. Within the State there is a well developed training scheme for the horticultural trades. Apprentices are indentured to employers

for four years. Normally, for the first three years, apprentices attend a trade school for 1 day a week, or for country students, they attend in blocks of one or two weeks for an equivalent period. There are two Centres — one at Oakleigh Technical School and one at Collingwood Technical College. There has been a very dramatic increase in the number of apprentices employed (Table 1).

Table 1. Number of persons in horticultural trade training in Victoria

Year	No of New Indentures	No Completing	No at Schooling
* 1968	31	6	24
1969	41	6	63
1970	35	10	88
1971	40	5	100
1972	63	18	144
1973	84	36	181
1974	85	29	208
1975	85	42	224
** 1976	165	69	213
1977	155	62	380
1978	259	92	570
1979	298	121	734

* Horticultural Trade — Gardening and Turf Management
** Horticultural Trades — Gardening,
— Turf Management,
— Landscape Construction,
— Nurseryman

In 1976 the single trade was divided into 4 separate trades with a number of common units — and then separate units for each trade.

What we need to understand clearly is what each level of training aims to achieve. Trade training leads to a "Certificated Gardener" — these are practitioners. However their training does not include management training.

Burnley Horticultural College offers three-year full-time courses (or equivalent part-time courses) leading to the award of a "Diploma of Applied Science in Nursery Production and Management," and a "Diploma of Applied Science" in Amenity Horticulture." These students are trained in all aspects of management as well as receiving a thorough training in practical skills. Mr. McCure will give greater details of the actual methods used in the nursery section. The number of students enrolled is shown in Table 2. This also shows a marked increase in demand. At both the trade level and the diploma level there are currently more applicants than can be trained in the three institutions.

These two levels of training complement each other. What there is not, either in Victoria or elsewhere in Australia, is a degree course in amenity horticulture. There is a need for a

small number of highly trained technologists. Some of these will be required in industry and some will be required in research and teaching.

Table 2. Number of persons in diploma course at Burnley Horticultural College

Year	Total Number Enrolled
* 1956	30
1966	62
** 1967	56
1968	63
1969	66
1970	83
1971	80
1972	93
1973	98
1974	104
1975	122
1976	119
1977	113
*** 1978	136
1979	127
1980	148

* Certificate of Competency in Horticulture
** Diploma of Horticultural Science course commenced (Diploma of Horticulture course commenced in 1958)
*** Diploma of Applied Science in Amenity Horticulture
Diploma of Applied Science in Nursery Production and Management
Diploma of Applied Science in Horticultural Crop Production and Management

One of the most obvious features of the amenity horticultural industry (and in that I include all aspects of nursery production) is the lack of research. There are three reasons for this: —

(i) There is no Australian university course in amenity horticulture and therefore little encouragement of post-graduate work
(ii) There is no government department of horticulture. Most, like Victoria, include it with agriculture where it receives scant attention. Of the 205 Victorian Departmental Programmes only 6 refer specifically to amenity horticulture.
(iii) The various sections of the industry are poorly organized and have few pressure points in parliaments. (This must be copared with the cattlemen and their extremely strong political voice which has resulted in their achieving very considerable research).

This lack of research has resulted in a slow rate of development of the industry; it also results in a lack of focus of attention on the industry. These are both reflected in the low status accorded horticulture.

A high standard of training and a high standard of research are often linked together. Teaching staff involved in research are kept at the frontier of knowledge. Without research, staff tend to

teach what was, rather than what is coming. Staff at tertiary institutions teaching horticulture should be involved in at least limited research. I believe my own institution suffers from a separation of teaching and research. This must affect both the students and subsequently the industry.

I believe that at least these three levels of training should be available. Because of the large numbers involved, there should be a trade training scheme in each State. This should be consistent throughout the Commonwealth. There will necessarily be differences in each State, reflecting the local horticultural plants and practices. The establishment of training at this level is essential if the industry hopes to gain recognition, otherwise it will remain with the old "gardening" image.

In considering the establishment of diploma and degree courses, careful consideration should be given to the number and type of courses. However special attention should be given to utilizing courses, subjects, and facilities of existing teaching institutions.

Finance for education is becoming more and more limited. The one advantage of this is that the various institutions are having to look very closely at their courses. They can no longer afford to ignore the wishes of industry. For this reason, any organization, such as the I.P.P.S., has no need to be fearful in approaching a training institution with suggestions for modifying courses. Indeed most institutions, but not all, notably universities, have course Advisory Boards or Committees with industry representation.

As I mentioned previously, finance for education will be limited. But is is not only in education. Politicians are no smarter than anyone else. Anyone who believes that politicians by themselves can or will sit down and determine the correct priorities for the community and will provide the finance accordingly is living in a dream world. Politicians (Federal, State and Local Government) respond to advice provide to them. If they don't get any advice, no money is provided. Horticulture has suffered from us all being absorbed by our nurseries, by our plants. We have not put enough time into supporting our organizations and preparing submissions. Unless the industry becomes more professionally organized, the industry will continue to suffer both financially and in its professional standing.

Recognition for the craft and profession of the plant propagator is important. It involves adequate financial reward for those in the industry and it involves an equitable share of government resources being directed to the industry. Education and training can and does assist in gaining this recognition. However, each of you here today have an obligation to be involved with the train-

ing insitutions and with your various organizations. On the one hand you need to tell the training institution what is required and on the other you need to ensure that those institutions get the staff, the finance, and the facilities to provide it.

HYDRAULIC ENGINEERING RELATIVE TO PLANT PROPAGATION

LESLIE R. HALL

Ris Irrigation Systems,
Elizabeth, South Australia.

1.0 INTRODUCTION

The basic aim of an irrigation system designer is to design a system capable of applying equal and even amounts of water in a controlled fashion to every plant within the system as required by the plant.

This aim is common to every system whether large or small. Such a system allows application of the optimum water requirement to each plant, thus optimizing production. The plant or plants depending on this system are usually of high value, when taken in terms of crop loss, lack of seed germination, reduced growth or replacement of the plants. Hence there needs to be a greater appreciation of system costs in relation to possible losses incurred by poor system performance.

In the practice of plant propagation the system becomes a part of the environmental control rather than solely an irrigation system. However many of the same principles of hydraulic design apply and the requirement for correct performance becomes of even greater importance.

Engineering technology today is sufficiently advanced to enable the development and installation of some very sophisticated irrigation systems but pure theoretical knowledge is not sufficient to guarantee optimum performance of the plant or plants. The designer must be made aware of the practical requirements of the system and the problems associated with operation, installation, and interaction with other cultural operations.

The user of an irrigation system is not required to have a detailed knowledge of the irrigation componentry and of irrigation system design. The most critical task which the user performs is the specification of the system which will suit his requirements and consequently he must either communicate this to the designer or manufacturer or select the equipment which will perform his specified task.

The object of this paper is to provide guidelines in preparing

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specifications and to give a basic understanding of design decisions.

2.0 SYSTEM TYPE AND LAYOUT

Systems used in plant propagation are basically mist or fog systems. Such systems differ from normal spray systems merely in the type of emitter used and in the operating pressures.

The system will comprise a water source which may be either mains or pumped supply, a main pipe to the control valve (or valves) and a distribution network of lateral pipes feeding to each emitter. To ensure optimum and equal performance from each emitting device the distribution network must be designed such that pressures are approximately equal over the whole network. The main itself must be capable of supplying the required quantity of water to the valves without unwanted loss of pressure or flow and the water source must be sufficient for all requirements.

3.0 EMITTER CHARACTERISTICS

3.1 Discharge Characteristics. The emitter will essentially be some form of misting (or fogging) jet. The unit may be merely a fan spray operated at very high pressures or a nozzle and deflector plate type.

Each type of misting unit is essentially an orifice with a pressure discharge characteristic defined by:

$$Q = Ca\sqrt{2gH}$$

where Q = flow through nozzle

a = cross sectional area

g = acceleration due to gravity

H = head pressure

C = nozzle constant

A plot of discharge versus pressure for any nozzle will take the form of the plot shown in Figure 1.

Note that nozzles become increasingly less sensitive to pressure variations as the pressure increases. This may be of benefit in limiting discharge variations between emitters but can also result in the need for increasingly larger pressures if application rates need to be increased. Such pressures may not be available from the source or may be uneconomic to maintain and hence it may be necessary to change to a larger nozzle.

3.2 Allowable pressure variations: Misting systems are usually controlled by some form of moisture sensing device placed at a discreet point within the system. The application levels at this point are assumed to be representative of the whole area covered

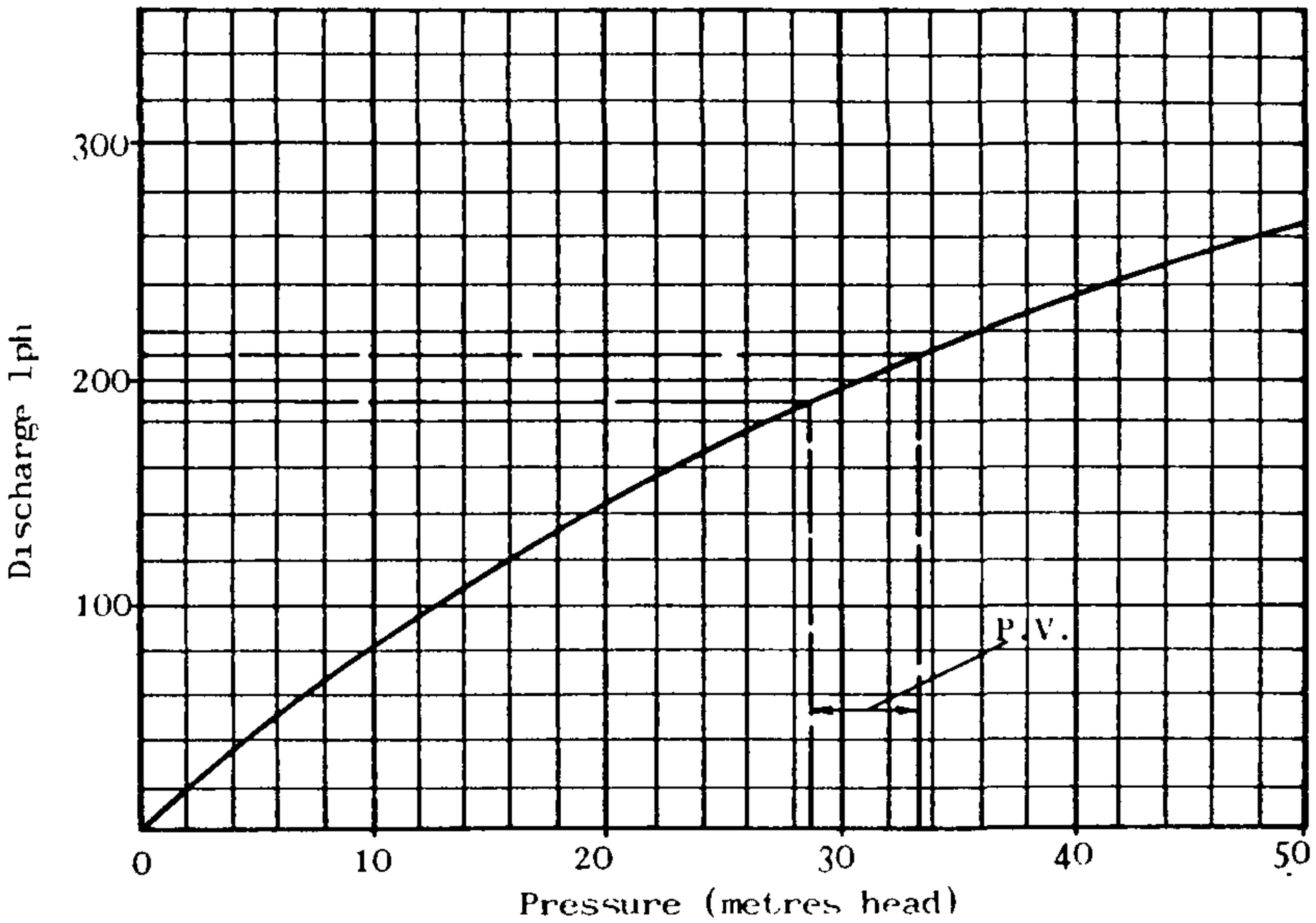

Figure 1. Discharge pressure curve for misting sprinkler

by the system so it is necessary to maintain nozzle discharges throughout the network at approximately equal rates to avoid net accumulations or declines in moisture levels at other points within the system.

Figure 1 shows a nominal operating pressure of 31.5 metres head and a nominal discharge of 200 l.p.h. If we are to assume that a discharge variation of $\pm 5\%$ is acceptable (from 190 to 210 lph) then pressures within the system must be maintained between 29 and 34 metres head for correct performance. Actual pressure discharge characteristic curves may be obtained from the manufacturer. Characteristic curves will vary depending on the type of emitter (due to variations in the nozzle constant C).

3.3 Diameter of throw — spacings. With normal sprays and sprinklers an increase in pressure results in an increase in diameter of throw. This is not necessarily true of a misting spray where increased pressures result in a smaller droplet size (and hence greater misting). It is possible that the diameter of coverage may even decrease slightly. Hence it is advisable to assume that the diameter of coverage of the sprinkler is constant over the operating pressure range and design the sprinkler spacings accordingly.

Misting sprinklers generally have a precipitation variation as shown in Figure 2. This is very approximate and will vary with type.

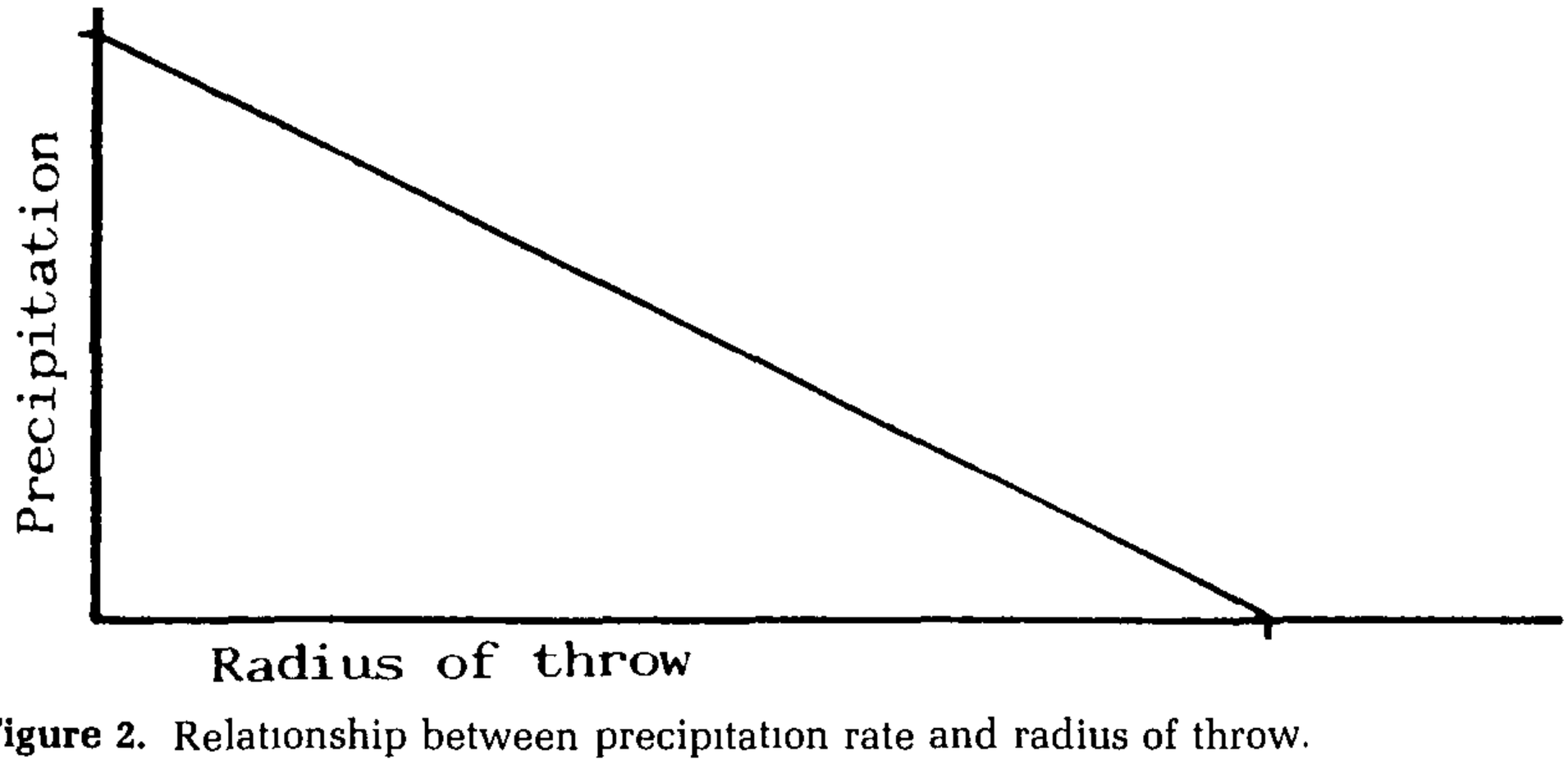

Figure 2. Relationship between precipitation rate and radius of throw.

The figure does indicate, however, that it is necessary to place the emitters at a spacing approximately equal to the radius for even application. It may be found necessary with some types of emitter to decrease the spacing even further.

In all cases a triangular placement of the nozzles will result in more even coverage if more than one run of sprinklers is necessary to cover the propagation beds.

4.0 HYDRAULIC DESIGN — PIPE DESIGN THEORY.

Pressure (or head) is lost in friction between the moving water and the wall of the pipe. Pressure is also lost in lifting the water up to a higher point (conversely pressure is gained in a downhill situation). The equations governing the flow of water are as follows:—

$$H_1 + Z_1 = H_2 + Z_2 + H_L - (1)$$

where H is the head (in metres or feet of water)

Z is the height of the point above some known datum (metres or feet)

H_L is the head loss due to friction incurred due to the flow of water between points (1) and (2)

The headloss due to friction may be calculated as follows —

$$H_L = f \frac{v^2 l}{2gd} = f \frac{8q^2 l}{g\pi^2 d^5} - (2)$$

where v = velocity of flow
l = length of pipe between points (1) and (2)
d = internal diameter of pipe
g = acceleration due to gravity (9 81 m/sec/sec)
q = flow
f = friction factor depending on the surface condition of the pipe

The friction loss for various flows for all types of pipes has been plotted in graphical form and produced by the manufacturers. However the formula (2) allows some pertinent observations to be made.

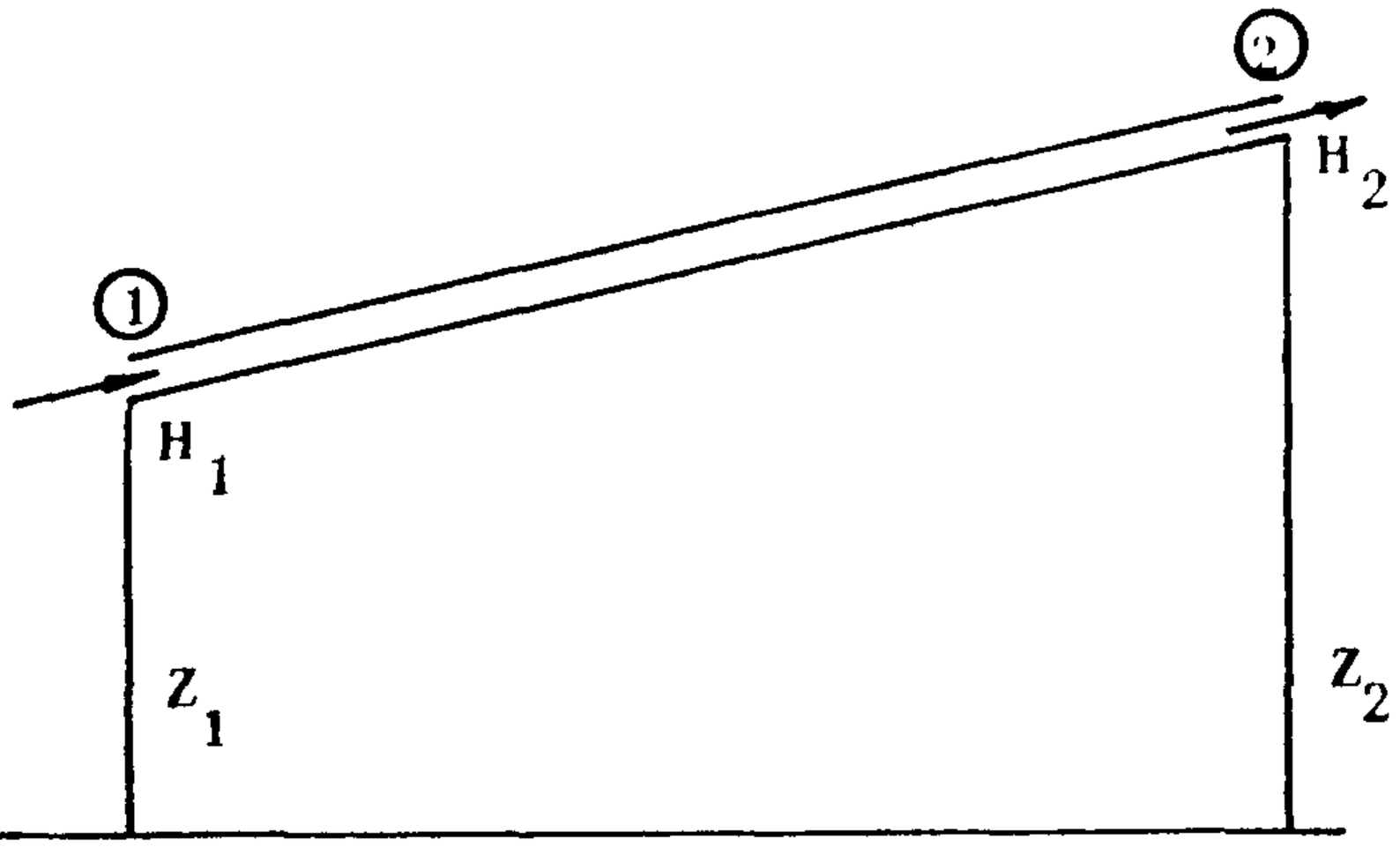

Figure 3. Pipe design formula

Increasing the length of the pipe will directly increase the pressure loss due to friction. Increasing the diameter of the pipe will decrease the pressure loss due to friction. Increasing the flow will increase the headloss due to friction.

Note that the headloss is dependent on the square of the flow. Thus doubling the flow will result in four times increase in the headloss.

Friction losses depend on the type of pipe used (Table 1), (i.e. variation in the friction factor f).

Table 1. Friction loss for various pipes with a flow of 2 5 lps (33 gpm) through nominal 50 mm (2″) Class 6 pipe

Material of manufacture	head loss (metres/1000 metres of pipe)
P V C pipe	21
High density poly tube	32
Asbestos cement pipe	37
Med galvanised iron pipe	48

The variation in headlosses as shown in Table 1 is due to differences in both roughness and internal diameter. For example, high density poly tube is as smooth as u P.V.C. pipe but the diameter is small (e.g. nominal 40 mm diameter H.D. poly tube has approximately the same internal diameter as nominal 32 mm diameter uP.V.C.) Note that the surface condition of the pipe becomes of great important where it is intended to use existing pipework. Increased friction losses may be incurred due to growth of material on the pipe walls. This is especially true of galvanised iron pipework.

5.0 HYDRAULIC DESIGN — DESIGN EXAMPLE

Sprinkler lateral design. As mentioned in Section 3.2 it is necessary to limit pressure variations within a lateral to the

pressure variation as calculated from the discharge pressure characteristic curve. If we continue with the emitting device as indicated in Section 3.2 and assume that we have ten such nozzles spaced at 1.5 metre intervals along a 15 mm Class 15 P.V.C. pipe, what then is the pressure variation along the pipe? Pressure losses for the 15 mm PVC pipe are shown on the flow resistance chart with pressure losses shown in metres head/1000 metres of pipe.

Example Calculation. Nominal nozzle discharge 200 lph (0.056 lps):

flow lps	head loss metres/1000 m	actual head loss in 1 5 m pipe
0 056	—	—
0 11	16	0 024
0 17	34	0 051
0 22	54	0 081
0 28	86	0 129
0 33	110	0.165
0 39	145	0 218
0 44	245	0.368
0 56	275	0 413
TOTAL		1.71 metres

Note actual head loss is head loss per 1000 metres of pipe $\times \frac{1\,5}{1000}$

From Section 3.2 the allowable head variation is from 29 to 34 metres head or 5 metres variation.

Hence, the above design is well within the tolerances dictated by allowable pressure variations.

5.2 Mainline design. Mainline design follows the same principles as applied in the previous design example with the additional factors that heights along the main may vary and that the flow will be constant over the length of the pipe.

In the design of the main the allowable pressure loss over the length of the pipe is the difference between that pressure available at the source and the pressure required at the controlling valve.

For this example we will extend the previous example and assume that three laterals are to be run at one time giving a total required flow of 1.7 lps. We will also assume that the water source is 120 m distant and provides a pressure of 50 metres. Assume a lift of 10 metres to the valves and note that the required operating pressure is to be 34 metres head from Section 3.2.

Example Calculation. Formula $H_1 + Z_1 = 8_2 + H_L$ (from Section 4.0)

H_1 = 50 metres head

H_2 = 34 metres head

$Z_2 - Z_1$ = 10 metres (the difference in height between points 1 & 2)

Hence

The head loss $H_L = H_1 - H_2 + (Z_2 - Z_1)$

$= 50 - 34 - 10$

= 6 metres head

For various sizes of pipe the head losses for a flow of *1.7 lps* may be calculated from the flow resistance chart:

Size of pipe	Head Loss metres/1000 m	Actual head loss over 120 metres
25mm Class 12	170	20 4
32 mm Class 9	58	7.0
40 mm Class 6	27	3 2

As the pressure losses in both the 25 mm and 32 mm main are above the allowable loss it would be necessary to select the 40 mm mains size.

6.0 ASSESSMENT OF WATER SOURCE

6.1 Type of Source. The source of the water may be either direct from mains or from a pumped supply. In a number of cases the latter system may be repumping mains water.

6.2 Mains Supply. The flow available from mains supplies will depend on the size of the meter available and the pressure in the mains network at the take-off point.

From our previous example to run these laterals at one time a flow of 1.7 lps was required. To achieve this from main it may be necessary to have up to a 32 mm water meter. However to run one lateral at any one time would require only a 20 mm meter.

To assess the suitability of the supply it is necessary to measure the pressure and flow available at the meter and to compare this with the flow required to operate the desired number of emitters. The appropriate government department may be of some assistance in establishing the performance characteristics of the metered or mains supply.

6.3 Pumped Supplies. In order to specify the characteristics of the pump required it is necessary again to establish the flow required. In addition the necessary pressure at the pump must be specified.

In the previous example (Section 5.2) a flow of 1.7 lps is required. The head pressure required is 51 metres if a 32 mm Class 9 main is used or 47.2 metres if a 40 mm Class 6 main is used. Such details may be forwarded to the pump manufacturer along with the suction condition. The manufacturer will then propose a pump capable of performing the required task.

7.0 ANCILLARY EQUIPMENT

7.1 Pressure Control. To achieve continuous optimum performance from a system, pressures must be maintained at the required level at all times. Where the input pressure from the source is constant (such as a pumped supply) pressures may be maintained merely by adjusting the valves at the head of the lateral.

Many systems are operated directly off mains, however, and pressures will fluctuate over a 24 hour period and from season to season depending on area usage. In this case some form of automatic pressure control is necessary and there are a number of different types of valves available which will achieve this. In specifying these valves it is necessary not only to give the required downstream pressure but to indicate the flows at which this pressure is to be achieved.

7.2 Automatic Control. The rapidly cyclic nature of mist propagation systems makes control by some form of automatic sensor a necessity. While it is not within the scope of this paper to enter into discussion on the forms of control available most systems operate an electric solenoid valve to turn on the water.

Electric solenoid valves operate by use of a pressure differential and spring force on a diaphragm within the bonnet of the valve. Various types have differing opening and closure speeds. This must be established empirically. It is, however, unwise to use a valve with a very high opening or closure speed especially in high pressure systems as the resulting water hammer may cause pipe damage

It is necessary to ensure that the valve is of sufficient size to pass the required water flow without incurring undue pressure loss. It may also be necessary to ensure that the valve is fitted with manual flow control so that operating pressures may be set at the required level.

7.3 Filtration. Mist propagating systems utilise emitters with a very small orifice. It is essential to ensure that water sanitation is at a high level so that plugging of emitters does not occur. Where inorganic material is the expected blocking agent a screen filter may be used. It is recommended however that a screen with a mesh opening size of ⅓ of the orifice size be used.

Note that mains water will also require filtration to this level. Where organic material can be expected it is usually necessary to incorporate some form of sand filtration into the system using sand of between 10-25 particle size.

Note that as with all fittings, valves, etc. within the water flow, pressure losses will be incurred across the filter. When allowing for available pressure at the supply it is necessary to

incorporate the pressure loss across the filter in the dirty condition, not the clean loss.

COLLECTION AND TRANSPORTATION OF FIELD CUTTINGS

RAY AITKEN

Wildflower Nursery
Wanneroo, Western Australia

The first task in preparing for a field trip is to organize efficient insulation of the vehicle floor.

In our climate, the transfer of temperature through the chassis and vehicle floor frequently raises the floor temperature above tolerable levels. It has been found that a false floor of pressed packs available for seedlings, is excellent insulation.

MATERIALS REQUIRED FOR LENGTHY FIELD TRIPS ARE AS FOLLOWS:

1. Large "poly" boxes with efficient self-sealing lids.
2. A large quantity of paper (Butcher's paper for the purist — newsprint for the rest).
3. A plentiful supply of water, preferably carried in small, easily handled square containers of 4 to 5 litre capacity.
4. A squeeze pack or hand operated vaporiser.
5. Medium sized clear plastic bags plus some hessian or woven plastic bags.
6. Sphagnum moss.
7. A quantity of unexpanded cardboard cartons and appropriate tapes and ties.
8. A substantial piece of shade cloth which may be rigged to cope with direction shifts and sun intrusion.

TAKING CUTTINGS

Wherever possible the material should be collected shortly after daylight.

The material should be partially reduced immediately and wrapped in moist paper before stowing in a "poly" box, or into a cardboard carton.

At night camp, further reduction may be made but never to the prepared cutting stage.

Advantage should always be taken of night temperatures and possible dew. However, material should be protected from winds.

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Best results are obtained with prodigal use of fresh moist paper at each unwrapping and the use of moist sphagnum scattered through the cuttings and wrapped around exposed bases can be highly commended. If water from the field is to use always test first, i.e. with the taste buds. Brackish water has a very adverse effect on material which is to be transported for days or weeks.

There are many more sophisticated means of collection than those mentioned here. Use has been made of ice, dry ice, refrigeration and air conditioning. However, lengthy field trips are generally dependent on the use of quite unsophisticated means and often in unsophisticated vehicles.

There are some collectors who use Formula 20, the old Geo. Warner solution. There is some evidence to suggest that this material does delay wilting. My own experience seems to indicate that it has considerable value when dealing with lush cuttings, but is not effective with woody types. Further, in the case of dry desert material, it appears to have an adverse effect.

Perhaps emphasis should be put upon the continuous rehandling of collected material. One has to face up to the fact that extended field trips are expensive. It is, therefore, necessary at the end of a long hard day in the field to face up also to the essential labour required to deal with the material collected every night.

Plastic bags are great aids but they cause quick heating and there is always the ethylene danger. Our normal method is to collect material into plastic bags as carrying tools, but on arrival at the vehicle, we reduce the material and become dependent on moist paper.

Where airports may be reached easily, the additional travelling should not be neglected. This pre-supposes that air schedules are well known and that nursery organization has been arranged for receipt and treatment of material. For despatch by air, the material should be re-wrapped, placed in plastic bags and thence to the cartons. Sometimes this exercise causes damage through over-packing. It is false economy to pack too tightly in an effort to save the freight on a second carton. Sometimes this final packaging occurs in the vehicle on the way to the airport to save time.

When one is making a trip where no alternative transport is available, careful planning is necessary to keep the length of a trip to a minimum. Every day material is carried may reduce its viability. However, if a long period becomes necessary, then careful and continuous handling of material may still ensure success. Myrtaceous cuttings, for example, have been carried for as long as three weeks under very adverse summer conditions

and yet achieved a better than 50% result in the cutting trays.

When the transportation period is extensive, sphagnum moss has a definite part to play. Provided plant material is generously wrapped in moist sphagnum and kept reasonably cool, it will carry in good fettle. However, material in sphagnum which warms will degenerate very quickly indeed.

Summer collecting presents special difficulties. Mention has been made of the use of plastic bags as a carrying tool while collecting. Water should be on hand if only in a belt bottle, so that the inner surface of the bag may be made moist. The standard method of achieving this is to pour a little water on the material in the bag, shake vigorously and pour off the surplus. Normally one carries a second bag, preferably hessian to contain the plastic bag and insulate it. The outer bag is also kept moist to obtain an evaporative cooling effect.

If collecting in station country or farming areas, contact should always be made with local residents as quite often someone may be headed for the city and thus provide a quick fortuitous means of transport. I must record, however, that I once lost the product of three days hard collecting in this way, and never managed to discover whether the material was successfully delivered to one of my competitors, or found its way into a hotel garbage bin. Fortunately such tragedies are rare.

Whenever possible, transport should be at night, If collection is made as suggested, in the early morning, it is easier to keep the material cool in the comparative comfort of a camp than on the road in the heat of the day. This is particularly important when making desert collections.

Great care should be taken in the choice of camping sites. They should be as close to the plant source as common sense and topography allow. Of course if this can be achieved on good water, one has a bonus. While the quality of water for direct contact has been emphasised, most water can be used for cooling.

These notes have been written after many years, now approaching half a century, of collecting. The methods detailed are simple enough and we all have our own ideas in this respect. The justification for detailing them is simply that they have proved fairly effective.

EDUCATION AND TRAINING OF THE PLANT PROPAGATOR IN THE 1980's

IAN G. McCURE

Burnley Horticultural College
Richmond, Victoria

THE PRESENT

The plant propagator of today is not only a craftsmen but also a technician. The environment in which cuttings or seeds is placed, is now equally important as the techniques used in preparing them. In the past decade, advances in technology have become as much a part of the nursery industry as any other enterprise. There is a greater understanding of HOW a plant functions, WHY it develops, and WHAT is required to make it grow. With improved growing systems and sound business management, there is now greater potential for efficient plant production than ever before.

THE NEXT DECADE

In the next decade there will be a continuing need to develop more efficient methods of production and energy conservation to offset increasing costs of production and reduced net profits. It will be increasingly important, not only to train the propagator to be proficient in skills and techniques, but also to ensure he has a thorough understanding of plant development and be able to make the most of the environmental technology he has at his disposal. The propagator will also need to be able to recognise the trends of change and to translate them into profitable applications to the nursery business.

The EDUCATIONAL area of training will become increasingly important to the propagator and to the nursery business in the future. The propagator will need to be a motivated and skilled technician with an awareness of how the plant is best propagated and raised to a saleable state at minimum cost and how that plant will suit the environment in which it is to be grown. You may well say, surely it is up to the manager to determine production and profitability. Certainly, but the propagator needs to be part of the operation and to be educated accordingly.

TRAINING REQUIREMENTS

Demand for trained people in the nursery industry will increase in the next decade and will include further development of both full-time and part-time courses which exist at the various educational institutions and colleges.

There will be an increasing demand for training and retraining of personnel working within the nursery industry, particularly in the form of short courses, seminars, workshops and specialist courses in advanced techniques. Educational institutions and colleges are now aware of the need to provide courses of training which are relevant to the needs of the horticultural industries.

TRAINING OBJECTIVES

The aim in educating and training plant propagators is to provide a sound understanding of plant growth, development and production techniques.

This can be achieved by practical skills training interlaced with a theoretical background of principles and related practices. Subjects will include plant science, plant protection, and plant nutrition. Other areas of training must include management, economics, marketing, engineering and plant identification.

In areas of practical application, it must be remembered that the student will learn best by DOING. At least 70% of the time allocated for a topic should be spent in practicing. It is not sufficient for the student to be familiar with the technique of taking stem cuttings. He must be able to select the material, treat it, place it in the right environment, pot up the cuttings, grow them on, and be aware of the many factors involved in producing a marketable product. He must be able to get a result. If he doesn't, he needs to know why.

This initial practical training is the responsibility of the educational institution. The necessary additional practical training is the responsibility of the nursery industry.

DIPLOMA COURSES AT BURNLEY HORTICULTURAL COLLEGE

After extensive consultation with the horticultural industries, Burnley Horticultural College began in 1978 a revised three-year diploma course designed to cater primarily for people desiring a career in nursery and amenity and ornamental horticulture. Specialisation was introduced, and Diplomas of Applied Science in Nursery Production and Management and Amenity Horticulture, were instigated.

An important addition to student training is the inclusion of the Industry Experience Programme of practical employment at the end of the second year of the course. This is the 'sandwich course' system which has proved successful overseas. In the final year of the Diploma course students specialise in either Nursery or Amenity Horticulture.

Stages of Nursery Training for Diplomates at Burnley.

1. Initially the student is taught to develop an understanding of nursery practices, including the phases of growth, plant identification, culture and maintenance of the major groups of nursery plants. Training is structured to cover basic principles and practical skills associated with plant propagation. Being a common first year, the student also learns the basics of plant growth and management by exposure to other subject areas.
2 In the second year the student builds on his knowledge and acquires an understanding of the scientific principles and techniques used in nursery production. For example, he learns to produce native plants using the techniques and skills attained in first year. He learns to use tissue culture techniques to produce ferns and orchid mericlones
3. After the Industry Experience programme, the student specilises in management techniques and is taught to make the decisions needed to manage a nursery business. He also learns to evaluate the effects of changes in the environment in which his business is operating and develops the skills required of a competent nursery supervisor

Methods of Training the Plant Propagator at Burnley.

A close relationship between theory and practice is an important feature of training at Burnley Practical skills and related theory are taught according to the seasonal cycle of plant growth. For example, budding of ornamental trees takes place in late summer, half-ripe stem cuttings in autumn, and root cuttings in late winter. By exposure to good practical facilities, techniques applicable to the industry can be demonstrated and taught realistically and each student has the opportunity of achieving results from his efforts.

Nursery studies are taught in the following way:

1. *Classroom lectures* — the necessary theoretical background is taught by College staff and visiting experts from industry and horticultural research whenever possible.
2. *Practical sessions* — usually of half day duration with students in small groups. Apart from skills and technique training, maintenance of the teaching complex, demonstrations and record keeping takes place.
3. *Day visits to nurseries* — to illustrate commercial production of plants and flowers. These are timetabled on a regular basis and are an important application to training at the College.
4. *Tours* — usually of one week's duration, at least four are conducted during the three years of training. These tours enable the students to move further afield and see nurseries and areas of horticultural interest outside the limits of day trips.

5. *Plot work* — at the commencement of training each student is allocated an area of open ground (approximately 39 sq m), on which he must grow a range of plants. In the first half year vegetable crops are grown. The area is then planted with rootstock and scion cultivars which he propagates and raises to maturity. The student is responsible for the propagation and management of his plot area including pest, disease, weed control, and nutrition. This is a satisfying experience to the student and an excellent training method. Future additions will include the erection of polythene tunnels over the plot areas for cut flower growing.

Certificate of Horticultural Studies. Part-time courses being offered at Burnley include the Certificate of Horticultural Studies, which has been developed as an evening course for students engaged in working in some branch of the horticultural industry.

This involves units of the following subjects: Plant Propagation, Soil Studies, Plant Studies, Plant Function, Plant Pathology, Entomology, and Ornamental Plants. Each unit consists of 30 hours involving fifteen evenings, each of two hours extending over one semester.

Propagation for Nurserymen. An additional unit of part-time study, Propagation for Nurserymen, is available for those working in the nursery industry. This is a refresher course which concentrates on more advanced techniques applicable to nursery production and management.

Conducted over a duration of 30 hours, it can be slotted in as part of the Certificate of Horticultural Studies. Lectures used for this course include practising experts from the nursery industry and horticultural research.

Nursery Trends and Developments. Beginning in 1978, a two-day short course for people working in, or associated with the nursery industry, is now an established part of the College year. This course makes available information from horticultural research and current developments of importance within the industry. Response to this type of course has been overwhelming, and only 200 can be accepted because of Burnley's limited resources. Participants attend from throughout Australia. An important feature of this course is the availability of printed notes, which are also available as a reference for those not attending the course. Short courses, seminars and workshops are an important avenue for dissemination of knowledge and will develop further in the next decade. They are also a means of getting people together on common ground to discuss their ventures and problems.

Industry Involvement. For the educational and training processes of nursery personnel to be successful, industry must be

involved, not only in planning and assisting with practical training, but through membership of Advisory Committees, and by maintaining a close and meaningful link with the teaching institution and the staff involved in teaching. Unfortunately, trained and skilled teaching staff are scarce in Australia. Staff need training too, and they will become more efficient teachers by industry contact and observation, than they can from theoretical knowledge and limited college training.

Burnley Horticultural College and the Apprenticeship training schemes at Oakleigh and Collingwood are indeed fortunate to have the enthusiastic support of the Nurseryman's and Seedsmen Association, members of the International Plant Propagators' Society, and the many nursery enterprises within easy reach of the training centres.

In the next decade it will become increasingly important for the plant propagator not only to be a skilled technician, but to have effective knowledge of plant growth and development. He will also need to be aware of what is going on around him and have the ability to "trouble-shoot" when the occasion arises.

VIRUS-INDUCED DWARFING OF CITRUS

K.B. BEVINGTON and R.A. SAROOSHI
N.S.W. Department of Agriculture,
Dareton, New South Wales

A major change in attitude towards management of citrus orchards is the interest in smaller, densely planted trees which yield well and can be easily sprayed and harvested.

There are various methods currently being investigated to control tree size in citrus. A simple method is the use of a bud transmissible factor which can produce dwarf trees on certain rootstocks. This follows from work done in New South Wales which showed that citrus on *Poncirus trifoliata* rootstock inoculated with exocortis or scaly butt virus produced pronounced dwarfing, while trees on Troyer and Carrizo citrange and Rangpur rootstocks were less dwarfed. Most other citrus rootstocks did not respond.

Different inoculants produced varying levels of dwarfing on *P. trifoliata.* From these, two dwarfing budlines have been selected as future sources for inoculations. They are classed "mild" dwarfing budlines and produce moderately dwarf tress with no symptoms of scaly butt, periodic leaf drop or unthriftiness which can be associated with exocortis.

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A number of dwarf trials established at Yanco, Gosford and Dareton research centres have yielded promising results with Navel and Valencia oranges and with lemons. In all trials dwarfing budlines were inoculated into trees of known virus status. Dwarfing in other citrus species such as grapefruit and Ellendale mandarin is also to be investigated.

Small demonstration plantings of dwarf citrus on five commercial orchards made in 1973 and 1974 have given further information under different soil conditions.

COMPARISON OF POTTING MIXES FOR MACADAMIA NUT TREES

T. TROCHOULIAS

Tropical Fruit Research Station
Alstonville, New South Wales 2477

Abstract. Nine month old composted macadamia husks were tested with sand, soil and sawdust in a combination of potting mixes.

Sand and husks increased macadamia seedling height by 73% after one year in 10 containers while sand and sawdust depressed growth by 39% compared to soil and sand

Dry weight of leaves, stems, tap roots and fibre roots at the end of the experiment showed high dry matter in the leaves (61%) compared to *Pinus radiata* (49%) The shoot to root ratio was 4.6 compared to 2 1 recorded for avocados

The sand and husks treatment (1 1 v/v) would reduce the time for macadamia seedlings to reach graftable size by 9 months compared to sand and soil (1 1 v/v)

INTRODUCTION

The macadamia industry on the north coast of New South Wales has increased from about 100 ha in 1970 to over 1500 ha in 1980. This rapid expansion has resulted in a heavy demand for nursery trees. The time from the potting of seedlings to planting out of grafted trees is usually about two years. Slow growth of seedlings in soil and sand based potting mixes has forced nurseries to outlay considerable investment in floor space and materials to supply the demand for grafted trees.

Field observations have shown that unthrifty mature trees benefit from heavy mulching with macadamia husks. The husk is the fleshy green carpel enclosing the nut. Chemical analysis of 9-month-old decomposed husks show a larger concentration of most major and minor elements compared with red soil. (Appendix 1). An experiment was initiated at Dunoon via Lismore in July, 1979, and terminated in July, 1980, to examine the growth

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response of macadamia seedlings to a combination of potting mixes made up of red soil, sand, husks, and sawdust.

MATERIALS AND METHODS

Two month old seedlings of the D4 cultivar *(Macadamia tetraphylla)* from a single mother tree with four fully expanded leaves were planted in 10 l containers in the following potting mixes on a volume to volume basis:

1. Red soil)Wollongbar clay loam)
2. Red soil + sand (½ + ½) CONTROL
3 Red soil + husks (½ + ½)
4 Red soil + sand + husks (⅓ + ⅓ + ⅓)
5 Sand + husks (½ + ½)
6. Sand + sawdust (½ + ½)
7 Red soil + sawdust (½ + ½)
8 Red soil + sand + sawdust (⅓ + ⅓ + ⅓)

Two kg dolomite, 1 kg blood and bone, 100 g KNO_3 and 100 g KSO_4 per cubic metre was added to all combinations and mixed for 3 min in a concrete mixer. In September, 4 g of calcium ammonium nitrate (23 per cent N) and 0.2 g of Ess-Min-El (R) trace elements was added to each pot. In November and February 16 g of 19-2.6-10 (NPK) Osmocote (R) were also applied.

All seedlings were placed under 50% shadecloth for the duration of the experiment and watered by sprinklers at regular intervals. Each treatment was represented randomly twice in a block of 4 × 4 pots. Each block (replicate) was repeated 10 times which made a total of 160 pots.

The seedlings were trained to a single stem and measured for height at approximately four weekly intervals. At the end of the experiment the following measurements were taken from one plant in each block (total 80 plants): stem girth at 10 cm, fresh and dry weight of leaves, stem, tap root, fibre roots and ratios of the above parameters.

RESULTS AND DISCUSSION

The treatments did not affect the growth of seedlings for the first 120 days. From 180 days onwards the treatment responses separate out into three main groups. The accepted industry norm, red soil and red soil and sand, were not significantly different from each other; plants reached a mean height of about 55 cm in one year. Sand and husks, red soil and husks and red soil, sand and husks gave a growth increase of 73, 30 and 12% greater than red soil, respectively. On the other hand, red soil, sand and sawdust, red soil and sawdust, and sawdust and sand depressed growth by 11, 17 and 39%, respectively, compared to red soil.

The substantial growth response to the sand and husks treatment suggest that either the nutrient reserves in the 9 month old husks (Appendix 1) are available for some time to the seedlings, or that a growth promoting agent is released from the husks. This is in marked contrast to the sawdust and sand treatment which showed a growth rate of ⅓ that of sand and husks. The sawdust was from a disused sawmill site and had an age of 8 to 30 years (Appendix 1).

An examination of the effect of treatments on dry weights of leaf, stem, tap root and fibre roots in relation to total dry weight showed sand and husks to have a higher stem weight than all others and amongst the lowest proportion of fibre roots (Table 1).

Table 1. Effect of potting mixture on dry weight of macadamia leaf, stem, tap root, fibre roots as a proportion of total plant dry weight

	Leaf		Stem		Tap Root		Fibre Roots	
Treatment	Mean	S D	Mean	S D	Mean	S D	Mean	S D
RS	55 0	7 0	21 2	1.32	7 2	0.06	7 8	1.5
RS + S	44 5	6.8	21 5	0.78	6 6	0.06	13 1	2 0
RS + H	54 8	7 0	24 0	1 17	6 1	0 04	9.3	0 9
RS + S + H	58 4	7 1	21 3	1 31	5 0	0 06	10 6	1 1
S + H	51 5	6.7	27 6	1 34	6 3	0.05	7 8	0 4
Sd + S	45 3	6 8	16.8	0 76	8.4	0 06	17.3	1 8
RS + Sd	57 9	7 2	19 9	1 28	7 1	0 06	7 8	0 4
RS + S + Sd	49 4	7 1	17 4	0 96	6 4	0 06	12 3	1 5
S E	±0 18		±1 2		±0 6		±1 5	

The red soil treatments grew as well as neighbouring commercial seedlings and no obvious visual nutrient deficiencies were noticed in any of the treatments.

The incorporation of husks in potting mixes in a macadamia operation avoids hauling husks back to the field for use as a mulch. This haul-back operation is costly as evidenced by the need to develop an in-field macadamia nut husker in Hawaii (1).

Table 2. Fresh (FW— and dry weight (DW) growth parameters for macadamia (means of all treatments)

Parameter	*Mean*	*S.D*
Leaves DW/FW	0 51	0 15
Stem DW/FW	0 49	0.32
Tap root DW/FW	0 47	0 05
Fibre roots DW/FW	0 23	0 08
Leaf DW/total DW	0 61	0 06
Stem DW/TDW	0 21	0 05
Tap root DW/TDW	0.07	0 02
Fibre roots DW/TDW	0 11	0 05
Height	60 49 cm	22 13
Girth	7 39 cm	1 89
Height/girth	8 07	1 57
Height/total DW	1.16	0 29

A dry weight shoot/root ratio of 4.6 (Table 2) was more than twice as high as the 2.1 ratio found in seedling avocados by Yusof *et al.* (3) The leaf showed a high dry weight to fresh weight ratio (0.51) and as a percentage of total dry weight (61.0) was higher than that recorded in *Pinus radiata* (49.0%) (2).

The height of macadamia seedlings trained to a single stem can give a satisfactory estimate (ratio 1.16) of its dry weight (Table 2).

Most macadamia seedlings are grafted at a girth of 8 to 10 mm. The sand and husks treatment reached at this level under twelve months (Table 3). Other treatments would take 18 to 24 months before they are ready for grafting so the increased growth rate would shorten the turnabout of seedlings by an average of nine months.

Comparable growth rates are achieved by some nurseries but only with fertilizer inputs. Our system only uses small amounts of fertilizer and mainly waste materials.

Table 3. The effects of treatment on girth of macadamia seedlings at the end of the experiment.

	Girth (cm)	
Treatment	Mean	S E.
RS	6 8	0 42
RS + S	7 9	0 31
RS + H	9.7	0.50
RS + S + H	7 6	0 43
S + H	10 1	0.38
Sd + S	4 9	0 23
RS + Sd	6 3	0 30
RS + S + Sd	6 8	0 44
S E	±0 43	

ACKNOWLEDGEMENTS

This experiment was carried as part of a programme to assist macadamia research from the Rural Credits Development Fund I wish to thank Mr K Ainsbury, Manager, "Macadamia Plantation", Dunoon, for the materials, Messrs M Thorman and I Musgrave for technical assistance, Messrs R D. Murison and N Hunt for biometrical analysis and Consolidated Fertilizers (Brisbane) for chemical analysis

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Appendix 1. Chemical analysis of soil, sand, sawdust and husks, respectively, used in the experiments

Nitrate nitrogen (ppm N)	16 7	1.0	2 0	19.8
Phosphorus BSES (ppm P)	20	99++	23	99++
Phosphorus bicarb (ppm P)	25	32	35	99+
Potassium (ppm K)	120	23	120	2550
Calcium (ppm Ca)	600	310	4200	2150
Magnesium (ppm Mg)	166	150	620	840
pH (1.5 water)	5 2	5.2	4.6	6.1
Iron (ppm Fe)	205	67	200++	194
Copper (ppm Cu)	1 4	0.2	1 2	1 2
Manganese (ppm Mn)	27	8	62	130
Zinc (ppm Zn)	2.2	0 8	20 8	20++
Sodium (ppm Na)	13	18	44	310
Chloride (ppm Cl)	10	5	60	350
Conductivity (mmho/cm)	0 04	0.13	0.18	0 32
Organic carbon (%C)	3 30	0 25	5.0+	5 0+
Sulphate sulphur (ppm S)	44	99+	46 0	96.0
Soil colour	red brown	yellow brown	—	—
Soil texture	silty loam	sand	sawdust	husks

PEACH UNDERSTOCK FROM CUTTINGS

JOHN TEULON

Swanes Nursery
Box 17, Dural, New South Wales 2158

It has been the practice to market peach trees during the dormant months of the year. From a retail aspect this practice develops sales resistance as, during this period, the public does not display the same purchasing interest as during the summer period when fruit is available. The reverse attitude applies in the summer when field stock is not available until winter. In addition, field-grown containerised stock is usually large, lacks sales appeal, and is difficult to handle.

Producing rootstocks of 'Okinawa' (100 hours chilling required) and 'Nemaguard' (resistant to certain species of nematodes) from cuttings during spring, summer and autumn, is more economical and reduces the production time to a few months.

Rootstock tip cuttings are taken in the autumn (second week in April), disinfected with 1% sodium hypochlorite for 4 minutes, cut to 10 cm in length and slightly wounded at the base of the cutting by removing a small slither about 1 cm long by 2 mm wide. They are dipped in a hormone powder containing 0.2% IBA and NAA, and inserted into 20% peat-sand mix and placed on bottom heat at 18°C for four weeks. Misting must be reduced or stopped as soon as a reasonable callus is apparent. When rooted, these cuttings must be transferred to liner containers for wintering then, as root development begins in late winter, trans-

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fered to one gallon containers. As rapid root development takes place in early spring these stock are ready to bud with stored budwood by late October or early November. Three weeks after budding remove any ties or tapes. Shorten the height of the stock by 50%. As the bud develops, remove the remainder of the stock. Understocks must not be allowed to dry at any time during the first three weeks of budding — any stress during this period will greatly reduce the "take" or bud survival. This method will produce a sturdy saleable tree, in a container, by mid-summer.

Okinawa is a stock that commences growth early after a very short dormancy period and when autumn-budded it will produce trees by spring (late October), especially when budded with cultivars such as Maravilha or Flordasun. Stocks for this are produced by the method described above during spring and summer. Care must be taken to ensure that stocks are kept in a vigorous growing condition at all times.

Peach stocks produced by this method include: Nemaguard, Okinawa, Golden Queen, American Red, and Elberta.

A METHOD FOR PROPAGATING PITTOSPORUM EUGENIOIDES 'VARIEGATUM'

ROSS G. BURGESS

Ross Burgess Container Nursery
Melbourne, Victoria

The genus *Pittosporum* provides us with some 160 species endemic only to the southern hemisphere. One such cultivated species is *Pittosporum eugenoides* 'Variegatum.' This handsome creamy-white margined form is one of the finest of hardy variegated plants. It has become widely propagated by Australian nurseries since its introduction.

The cuttings are collected in winter, from early June to late July, once the autumn growth has firmed. The current season's growth is collected from the stock bushes in the early morning with the aid of secateurs and placed into disposable polythene bags.

The cuttings are placed in a Captan dip and are prepared with sharpened surgical scissors. These are very light and easy to use; you are not pushing against a spring so they are less tiring than secateurs and they are easier to keep sharp. Bottom leaves are pulled off and a basal cut is made below a node, where last season's growth matured. A wound approximately 2cm long is made on either side of the bud exposing the cambium and phloem tissues. The leaves at the top of the cutting are trimmed

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back by a third, in order to stop excessive transpiration; this allows easier placement into the cutting trays.

The wounded section of the cutting is treated with a basal dip of Seradix 3 and immediately inserted into the rooting medium. Cuttings may vary in size somewhat, depending on the type of growth collected; between 6 and 10 cm is ideal.

The cuttings are then placed in Speedling Cellupak polystyrene trays of 60 cubicles. The striking medium in these trays consists of 3 parts coarse river sand, 1 part peat moss and 1 part perlite, which has been pasteurized with a steam-air treatment. The cutting mix also includes Terrazole at 100 gms per m^3.

The trays are placed in an igloo on raised sand beds with bottom heat at 23°C under intermittent mist. Leaf drop is reduced by weaning the mist off as soon as the cuttings strike, generally after 6 to 8 weeks, and then adopting hand watering.

Once the majority of cuttings have struck it is important to transfer the trays as soon as possible to a shade house, as day temperatures often reach 35° to 40°C in the igloo.

A regular liquid feeding routine is adopted to force both top and root growth. It is especially important to develop a good root growth in order to take advantage of the Speedling system.

The pittosporum cuttings are generally ready to remove from the trays when a developed root system is evident. This enables one to pot in summer, around mid-December. They are transferred into 15cm rigid plastic pots containing a soilless growing medium and a slow-release fertilizer. The potting medium consists of milled pine bark, scoria (a volcanic derivative), and ligna peat (coal dust.)

For the next 8 to 9 months the plants require little attention other than a regular spray program with both non-residual and systemic fungicides and insecticides. Some trimming may be necessary to promote apical dominance and a top dressing of a 3 to 4 month slow-release fertilizer in mid-winter is recommended.

The *Pittosporum eugenoides* 'Variegatum' cuttings grow to a saleable size by early spring and are merchandised with a bamboo stake and quality label.

THE USE OF ATRINAL ON MARGURITE DAISY

BRUCE C. NAYLOR

Kirramar Nursery
Calamvale, Brisbane, Queensland

Since the concentration rates of Atrinal reported in the Schering information sheet vary from 5 to 10 ml per litre over a

back by a third, in order to stop excessive transpiration; this allows easier placement into the cutting trays.

The wounded section of the cutting is treated with a basal dip of Seradix 3 and immediately inserted into the rooting medium. Cuttings may vary in size somewhat, depending on the type of growth collected; between 6 and 10 cm is ideal.

The cuttings are then placed in Speedling Cellupak polystyrene trays of 60 cubicles. The striking medium in these trays consists of 3 parts coarse river sand, 1 part peat moss and 1 part perlite, which has been pasteurized with a steam-air treatment. The cutting mix also includes Terrazole at 100 gms per m^3.

The trays are placed in an igloo on raised sand beds with bottom heat at 23°C under intermittent mist. Leaf drop is reduced by weaning the mist off as soon as the cuttings strike, generally after 6 to 8 weeks, and then adopting hand watering.

Once the majority of cuttings have struck it is important to transfer the trays as soon as possible to a shade house, as day temperatures often reach 35° to 40°C in the igloo.

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Since the concentration rates of Atrinal reported in the Schering information sheet vary from 5 to 10 ml per litre over a

wide range of plants, we decided to use 7 ml/l. on Marguerite daisy plants 9 cm high and in new soft growth, sprayed as evenly as possible. After one week we could see yellowing of the tip growth. From then on our first trial was somewhat of a disaster. On many plants the leaves were hanging down, some started to go black at the leaf axils and gradually deteriorated. We lost about half of those treated; those that survived branched at every leaf axil. The yellow cultivars both single and double, were a complete disaster and we lost about 99.9% of those sprayed.

In our second trial, about a month later, we used an application rate of 4 ml per litre. About 2 weeks after spraying, side branching could be seen from every leaf axil. After about 4 weeks all plants were branching well while our control plants had a single stem approximately 10 cm higher than those sprayed. So we had a dwarfing action as well as good branching — that is, except for the yellow cultivars. They had blackened again and deteriorated very badly. We lost most of these again; those that did survive took a long time to come up to reasonable plants.

On another crop of daisies, about one month later, we repeated the process, only this time we tried an application rate of 2 ml per litre. The side branching was much less with only 3 to 4 leaf axils showing any signs of branching and growth was equivalent to that of the control plants. So at 2 ml per litre we had very little branching and growth was not retarded except, of course, on our yellow cultivars which were going the way of our past result.

The yellow daisies from another batch of plants were again sprayed at 1 ml per litre, but these again blackened and many died.

In July, after spraying a crop of daisies, the weather turned cool. We were now using 4 ml per litre on all but the yellow cultivars. This weather change, with the temperature falling to about 5°C, gave us the same result as spraying with too strong a mixture.

We noticed that after about 7 days there is a slight yellowing of the small leaves around the apical bud. This is quite normal when spraying with Atrinal.

In conclusion we have found that the 4 ml per litre concentration is quite satisfactory on all but yellow cultivars, providing that the temperature is above 5°C. It looks as though the yellow cultivars will have to be hand-pinched to get branching; we have found that Atrinal cannot be used on them at any strength without damage.

THE WHY'S AND HOW'S OF PASSION FRUIT GROWING IN QUEENSLAND

TREVOR DONCASTER

Mansfield Garden Centre
Mt. Gravatt, Brisbane, Queensland

In the early years, passion fruit growing in Queensland was simple. Seed of the purple passion fruit *(Passiflora edulis)* was sown either directly into the field, usually a newly felled patch of scrub, or transplanted from a seedbed.

The Woodiness virus, also known as "Bullet", because of the effect it had on the fruit, was sometimes present to a minor extent, especially during cooler weather, but did not cause any great concern. However, during the late 1940's it became so bad that production suffered severely.

Breeding Programme. A selection and breeding programme was begun at Redlands Horticultural Research Station, Ormiston. By the late 1950's several unfixed hybrids were produced, two of which were to become the mainstay of production, 'Redlands Triangular' (Selection 3-1) and Selection E-23. Selection 3-1 became the basis for the fresh fruit trade until the mid 1970's. Vines of this cultivar are not as vigorous as those of Hybrid E-23, and are less tolerant to Woodiness virus. In fact by the mid-1970's the incidence of Woodiness virus had become so severe that 3-1 was rapidly losing favour to E-23 and to less extent other hybrid selections released for grower assessment from earlier breeding programmes. Also during the 1950's plant losses from fusarium wilt were becoming serious and, in fact, nearly wiped out the industry in the older growing areas. Trials showed that the golden passion vine *(P. edulis* forma *flavicarpa)* was resistant to wilt. Spectacular results were obtained by grafting scionwood of *P. edulis* and selected hybrids onto *P. edulis f. flavicarpa* stock. Land which had been abandoned because of the wilt problem was able to be brought back into full production again.

Rootstock. The golden passion vine used for rootstock is very vigorous, often growing 8 meters or more in a season and flowering profusely Many vines are self incompatible and single vines often fail to set a crop. Pollination by one or more vines is often required to set a good crop of fruit. As well as having resistance to fusarium wilt, golden passion fruit is also resistant to nematodes. However, it is more susceptible to frost than the common purple or hybrid plants.

Propagation. Commercial passion fruit production in Queensland is now based on hybrid types. Wilt resistance is obtained by grafting selected scions on seedling rootstocks of resistant strains of *P. edulis f. flavicarpa.* Grafting is normally

carried out in the nursery but can be done on *P. edulis f. flavicarpa* seedlings which have been established in the field.

Rootstock seedlings are raised in seed boxes and when at the 2 to 3 leaf stage they are pricked into 100mm plastic pots. When they are 40 to 50 cm high they are cleft grafted with the selected scion.

The scion consists of a small piece of vine wood, usually the tip, about 80 to 100 mm long with the older leaves removed. The lower edge is cut to a fine wedge to fit neatly into the cleft in the stock and the union is completely bound with PVC tape. Grafted plants are ready for transplanting into the field after the graft has callused, which normally takes 4 to 6 weeks.

SPECIES THAT I HAVE DIFFICULTY PROPAGATING

ROY WHALAN
Whalan's Nurseries
Kotara, Newcastle, New South Wales

Eucalyptus ficifolia. One of the most difficult plants I have attempted to propagate is *Eucalyptus ficifolia*, the prolific and colourful Western Australia native.

This species is usually grown from seed and takes several years to flower. There is no way of guaranteeing the colour of the flower as a tray of seedlings will vary from white to several shades of pink and red, also orange and maroon. Gardeners buy what they believe to be a red or orange coloured *E. ficifolia*, and after waiting for years find that it eventually flowers an entirely different colour and could be white.

I have attempted to propagate these both from cuttings and by grafting. By selecting matured softwood cuttings I have rooted a small percentage.

The low percentage didn't worry me as I have found from experience that the few odd plants from a difficult-to-strike species can be grown on in containers and the cuttings from these will give a better percentage. Cuttings from their progeny will give an even better percentage until eventually the cultivar can become quite domesticated.

However, with *E. ficifolia* I found that when the few that I struck were potted into various soil mixes they lived for a period of time, some of them for several months or even years, but they eventually died.

I grafted *E. ficifolia* onto various rootstocks including *E. robusta* and *E. maculata* and quite a few of the grafts actually took, but the scion never grew. It stayed dormant for varying

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periods, in a few cases even years, with the rootstock eventually repelling it. I have never attempted to graft *E. ficifolia* onto seedling *E. ficifolia* stock!

Attempts are now being made to propagate *E. ficifolia* by tissue culture. However, I do believe that if I had a few more years on my side I could eventually successfully propagate *E. ficifolia* by cuttings or by grafting.

Ceylon hibiscus. During the early 1950's the Brisbane city council garden department imported several new hibiscus from Ceylon, introducing many new colours in both singles and doubles. They eventually made these available to the nursery trade and I purchased what I considered to be the best of them.

The hibiscus is such an easy plant to strike, one could drop a cutting on moist concrete and it would form roots. However, we found the Ceylon cultivars of hibiscus were both slow and difficult to strike, so I grafted them onto 'Mrs. George Davis' rootstock. They readily took and grew into nice plants, but the rootstock appeared to be too vigorous for the scion and started to sucker. The more we removed, the more the suckers came.

We tried de-eying the 'Mrs George Davis' cuttings, such as we do for rose briar, but this didn't stop them from suckering.

We eventually returned to growing them from cuttings and found that many that were difficult to strike earlier became quite easy when one selected the cutting material from container-grown plants.

Grevellia 'Robyn Gordon'. One of my greatest upsets was with *Grevellia* 'Robyn Gordon.'

I found this plant quite easy to grow and very easy to strike from semi-hard young wood and I distributed many plants of this cultivar long before it was promoted by a Queensland organisation.

Although my original parent plant is as healthy today as when it was first planted, my cuttings appeared to be affected by a disease that turned the foliage black, stunted the growth, and the plants that I did set out became stunted and died. I tried numerous soil mixes with no success.

I have received a new strain of 'Robyn Gordon' from Victoria and I believe that with the use of fungicides and a coarse, sandy soil mix I have overcome the problem. Before long I will have a strain of 'Robyn Gordon' as good as I grew a few years ago.

Acokanthera 'Variegata'. Acokanthera 'Variegata', better known as varigated *Toxicophlaea*, has proved very difficult.

Hazelwoods Nursery in Sydney was producing this cultivar

by grafting onto green seedling Acokanthera but they couldn't have met with a great success as they only had a few plants and one had to be lucky to purchase one.

I have for years been trying to grow them both from cuttings and by grafting but with very mediocre success.

The few that I managed to strike grew very slowly and made it difficult for me to test my theory (that cuttings from a struck cutting in a container gradually become easier to strike).

I have tried air layering, grafting on to green rootstock, as well as growing them from cuttings.

At present I am trying a new method of taking cuttings. I am of the opinion that the sticky, milky sap makes them very difficult to graft

Fortuniana rose rootstock. When I first went to Perth quite a few years ago I was amazed at the vigor of the roses. They were using a rambling rose named 'Fortuniana' as a rootstock; it was standing up to the heat and was thriving in the sandy soil.

We have a lot of sandy soil areas around Newcastle, where it is difficult to grow good roses, so I decided to try 'Fortuniana' rootstock.

I found it harder to strike than the *Rosa multiflora* that we were using. The plants from the bud stage developed into nice plants, but we found the plants didn't transplant as readily as did those on *R. multiflora* rootstock.

Our main trouble was that we had two different sets of roses on different rootstocks, which were costly in production and marketing, and our customers didn't appear to appreciate that we were trying to do, so we dropped the idea.

Container-grown roses. One of my worst mistakes was with roses.

We were growing thousands of roses each year as potted roses. We budded these during the summer in the open ground and the following winter we dug them and potted them in five-inch pots. About October or November we sold the potted roses in flower

In an attempt to save open ground cultivation and to make work easier for our budders we decided to produce our roses in containers. We planted our briar in September in two-inch tubes and as soon as budwood was ready in October we commenced budding.

The first briars we budded had very little top growth and very little root growth but we got almost 100% take with these. As the season progressed the briars got bigger and stronger and the take got less and less.

We found that the large briars had roots through into the trays and these were broken as they were removed prior to budding. This broke the sap flow and caused a poor take. We reverted to striking our briar in the open ground and budding them there.

Conifers. I have found many conifers difficult, yet the majority are so easy that one could kick a cutting along the footpath and it would grow roots.

Cupressus macrocarpa 'Aurea' (Syn.: Lambertiana Aurea) was once only propagated by grafting onto a suitable green conifer rootstock but by selecting and reselecting suitable parent plants I have found these quite easy to strike from cutting.

Cupressus macrocarpa 'Coneybear' (Syn.: Conybere Aurea') is very difficult to strike from cuttings. I have actually grown the odd plant on their own roots but they are very slow to strike and slow to grow when struck. They are easy to graft onto a suitable conifer rootstock.

Rondeletia speciosa. Many years ago I visited Richards Nursery in Toowoomba, Queensland, where I saw a delightful dwarf shrub in full flower. It turned out to be *Rondeletia odorata* (Syn.: *R. speciosa).*

They gave me the cuttings I wanted. I took soft tip cuttings and planted them as I would any normal softwood cuttings. They stayed alive for nearly a year before eventually one after another they rooted and were potted up. From there they took two years to grow into saleable plants.

This shrub, *Rondeletia odorata,* is still flowering in my garden. It appears to be always in flower producing clusters of vivid orange blossoms. Maybe somebody may be able to tell me how to develop it in less than three years.

JOHN TEULON: We have good success with variegated *Toxicophlaea* treated with 2% IBA.

MARK PETERSON: I suggest that the problem encountered with *Grevillea* 'Robyn Gordon' could be fungal and that spraying with Daconil can control it.

ELECTRONICS IN PROPAGATION

ROBERT A.M. CAMPBELL
Sprinkler Installations Pty. Ltd.
Melbourne, Victoria

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of many types, all with their built-in inaccuracies. We have now entered an electronic age and plant propagators should be availing themselves of this sophistication. Simple electronic devices enable the propagator to control moisture to the cuttings, with light and temperature variations being two of the major factors that have to be considered.

Types of devices currently used include time control with light sensing. This device has a misting duration period in seconds and an interval between misting periods in minutes. Also included is a light sensing cell (UV sensitive). The light sensor enables the cycle period between misting to be increased up to two hours during darkness. Timing equipment is normally used in controlled environment propagation houses and multi-station controllers are available.

Carbon leaf devices sense moisture level at the cuttings. Fine mist is applied to the cuttings. When the desired level of mist is obtained by pre-setting the resistance between two carbon rods mounted into an epoxy resin block, the electronic unit opens a circuit to the solenoid valve, so cutting off the water supply. As evaporation takes place both the foliage and the sensing block moisture levels are reduced. When the pre-determined level is reached the circuit closes on the solenoid valve and turns on the mist until the maximum level is reached again, and this cycle continues.

On an overcast day when humidity levels are high and the evaporation rate is lower the sequence of operation is less frequent. On a day when temperatures are higher and evaporation rates are higher, the frequency is much greater.

A propagation house having good air circulation will have a much higher evaporation rate at the cuttings than a propagating house with poor ventilation. Under these conditions very sensitive equipment is desired. An inherent problem with sensing probes is the quality of the water. Each time evaporation takes place salts from the water build up on the probe and so increase the resistance set on the controller. This affects regularity and the amount of mist applied. All types of sensing probes should be cleaned regularly.

When high salt levels create problems in controllers of this type, it would be advisable to use time-sensing equipment.

A weaning or hardening off unit can be connected to any of the units that have been discussed. This unit is an electronic counter and can be set with a 1:1, 1:2, 1:3, 1:4, ratio. Cuttings can be hardened off from the propagation bench by using this unit. We would normally tube up the struck cuttings and then place them on a weaning bench for 2 to 3 weeks and harden off using 1:2, 1:3, 1:4 ratios for this period. Some propagators carry out this

practice in the bush house with mist sprays installed.

A more sophisticated system involves the use of programmes to enable one to control all factors, such as light, bottom heat, ambient air temperatures (heating and/or cooling) and air circulation, allowing for extended daylight hours, and reduced daylight hours. The term given to this equipment is micro-electronics or computers. Propagation being carried out in controlled environment conditions could utilize a programme to control the environment. Moisture, bottom heat, and air circulation are the main factors to be controlled by a simple programme.

Mist cycles can be programmed within defined temperature ranges — for example, a three-second misting cycle every 15 minutes with a controlled temperature bottom heat of say 22°C and ambient air temperature between 15°C and 18°C with one air change every two minutes. This control can be achieved very simply with the use of thermisters (electronic thermostats) for sensing both air temperature and soil temperature. The signals from these devices are fed to the micro-processor. The inputs are then compared with the required conditions and predetermined responses are sent to the misting equipment, ventilation system, and soil heating equipment, as appropriate. The cost of such a system prohibits its use to all but the largest installations; however, future cost reductions are highly likely given to the current trends in the price of electronic equipment.

THE VEGETATIVE PROPAGATION OF GIANT BLUE MOSS (*Selaginella wildenowii*)

A.G. SONTER

Sonter's Fern Nurseries
Winmalee, N.S.W.

Giant blue moss has never been easy to propagate except by layering runners. This is not economically feasible, particularly if uniform plants are required.

In our tissue culture laboratory we have spent a great deal of time and expense endeavouring to mass produce this plant, but its very slow and erratic behaviour in flasks has so far excluded it from satisfactory tissue culture propagation.

The method described here is the most successful approach we have developed for this difficult subject. Many well advanced stock plants, preferably about six feet high and well branched, are required. At no stage should the stock plants or young plants be allowed to drop below 25°C minimum temperature, and high humidity must be maintained.

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First, the terminal shoots on all branches are pruned off. In four to six weeks time, on each branch the first axillary shoot back down the branch will emerge and a root will develop from axillary shoot. When this root is at least ¼" long the cutting can be taken with approximately 1 inch of original stem above and below the axil.

The cuttings are planted vertically with the bottom segment of the stem and the axil below soil level, and the shoot and the top segment of the old stem above soil level.

Plants are set into loose, well aerated, potting mix and watered regularly until established in six to eight weeks. Do not allow them to dry out.

Four to six weeks after taking the first cutting the next set of axillary buds down the branches will have developed, with the associated roots, and may be cut and planted. The process may be repeated every four to six weeks until eventually there is very little stock plant left. The stock plants may then be left for 12 to 18 months to regenerate.

Impatience is always rewarded with failure. Buds must not be cut until the root has definitely developed to at least ¼", and they need to remain on the plants as terminal buds for at least four to six weeks to initiate this root development.

We have tried most of the possible hormone and nutrient combinations to artificially induce shoot and root development, but to no avail. The system requires time, patience and lots of clean stock plants.

WHY I CAN'T GROW *TEMPLETONIA RETUSA* BUT CAN GROW BANKSIAS

ADRIAN G. BOWDEN

Adrian's Nursery
Thomas St , Jandakot, Western Australia

The title of this paper will become clear to you as we proceed. Firstly, *Templetonia retusa* is a very hardy shrub that does best in an exposed position and high alkaline soils; it is known to grown in soils at pH 8.5. It actually does best growing in broken limestone. As I am not about to use that as a soil mix, we then come to the other problems. The water that is used by our nursery has a pH of 5.5 and 13 grains per gallon total dissolved salts, contains hydrogen sulphide gas, and looks like gingerale. Coupled with a well-drained soil mix and excessive summer temperatures necessitating watering up to 3 times a day, you can see what is going to occur when one decides to grow a plant that is on the opposite end of the pH scale, compared to the

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water. Definitely not a "dollar plant" under our conditions Not impossible to grow, but highly unprofitable.

However, on the other hand, we grow a number of banksia's, approximately 25 species, and we can manage to do them very well. Our soil mix is made up of 6 parts sand and 4 parts Jarrah sawdust, making sure that the resulting mix is well drained and on the sandy side.

To the basic mix we add:

3lb per cubic yard — 9 mth Osmocote.
2lb per cubic yard — I.B.D.U. 31% N.
1lb per cubic yard — ferrous sulphate
3lb per cubic yard — dried blood.
2lb per cubic yard — fine ground limestone.

The whole lot is mixed in a concrete mixer for 5 to 10 minutes, and then the pots are filled by machine. Currently we are doing about 25,000 banksias per year. The filled trays of pots are placed outside under sprinklers on a 3" layer of ½" slag. The seeds are then pressed into the surface soil and covered about twice their own thickness. Timing of the planting is when the winter rains are around — in Perth you have to be quick or you can miss them. May until September we find is OK; the plants reached a saleable size by February or March. Supplementary feeding is by I.B.D.U. as a top dressing if they need it and, once a month, with liquid feed through the sprinklers using N150-P30-K70-Mg20.

PROPAGATION OF AVOCADOS IN SUB-TROPICAL COASTAL REGIONS OF QUEENSLAND AND NEW SOUTH WALES

JOHN V. POHLMAN

Redbank Creek
Queensland 4343.

The avocado (*Persea americana* Mill.), family Lauraceae, is a native of Central America and the West Indies. The avocado industry commenced in America about 1910. Prior to this it was only known as a backyard fruit. There are records in Queensland of two trees being planted at Buderim Mountain in 1908. Both trees bore fruit. A few Queensland growers planted trees around 1920 and attempted to market the fruit. I say attempted, because fruit had to be given away to get people to eat them. These early plantings consisted of seedling trees and were established in North Queensland and in the coastal regions of South Queensland.

There are three horticultural races of avocados, namely

water. Definitely not a "dollar plant" under our conditions Not impossible to grow, but highly unprofitable.

However, on the other hand, we grow a number of banksia's, approximately 25 species, and we can manage to do them very well. Our soil mix is made up of 6 parts sand and 4 parts Jarrah sawdust, making sure that the resulting mix is well drained and on the sandy side.

To the basic mix we add:

3lb per cubic yard — 9 mth Osmocote.
2lb per cubic yard — I.B.D.U. 31% N.
1lb per cubic yard — ferrous sulphate
3lb per cubic yard — dried blood.
2lb per cubic yard — fine ground limestone.

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There are three horticultural races of avocados, namely

Mexican, Guatemalan, and West Indian. There are also hybrids derived from crosses between these races.

Avocado trees can be propagated either by seed or vegetatively by grafting, budding, cuttings or marcottage. The avocado, in common with many other species of plants, is cross pollinated and seedlings rarely, if ever, come true to type. Yields and fruit quality from seedling trees are usually inferior to that of proven commercial cultivars such as Hass and Fuerte. Some years ago a Mr. Sheppard from California planted 1500 seedling trees in his search for improved cultivars. Finally, after some years, he selected only two as having some market potential. This shows the futility of planting an orchard with seedling trees.

Avocados are normally grafted onto selected seedling or marcotted rootstocks. Great care must be taken when selecting a rootstock as the rootstock will undoubtedly affect the performance of the grafted tree. Various aspects to consider when selecting rootstocks are vigour, susceptibility to frost, resistance to *Phytophthora cinnamomi*, and salt tolerance. Little information is available on the suitability of the various rootstocks for subtropical conditions, but in California preference is given to Mexican strains, mainly because of their frost resistance. Guatemalan stocks are also compatible with most scions and produce vigorous trees. However vigour isn't the only consideration, for smaller trees have many advantages in a commercial orchard.

The following is a list of the most commonly used rootstock types with a brief description of their main features.

Mexican. Californians claim that this rootstock is the most suitable as it produces the most lateral roots and is hardier. Trees grown on this rootstock are small, and it is somewhat resistant to frost, surviving temperatures of −5° to −7°C (20° to 24°F) for short periods.

Guatemalan. Trees on this stock are more vigorous and a little more salt tolerant than those on Mexican roots but are less resistant to frost.

West Indian. Trees on these roots can only be expected to do well in frost-free areas and are not used commercially in Australia at this time. However, they may be used at some future date because of their salt tolerance. The Israelis have a highly salt tolerant cultivar named Maoz. Perhaps this is worth trying where salt is a problem.

Duke 6 & 7 (Mexican). Roots of these trees have some resistance to *Phytophthora cinnamomi.* Marcotted plants are being used as a rootstock by some nurserymen.

'Topa Topa' and 'Mexicola' are other Mexican cultivars currently being used in Queensland.

In the past we have been mainly concerned with resistance to *Phytophthora;* now, however, steps have been taken to control sunblotch virus or viroid. Sunblotch is transmitted in infected budwood and seed, or by naturally occurring root grafts between trees in an orchard. Apparently some researchers have succeeded in transmitting the viroid in pollen and mechanically; however, I have not seen this literature personally.

The Australian Avocado Growers Federation, in association with the Department of Primary Industries in Queensland and the Agriculture Department in New South Wales, have imported a *nucleus of seed and budwood which is free from sunblotch* virus. As a result, approximately 5% of all plantings in Queensland this year (1980), will be produced from indexed stock. Indexed cultivars currently being produced are Hass and Fuerte (and Sharwill by the end of 1980).

PROPAGATION AND GROWING HOUSES FOR AVOCADOS

Glass, or fiberglass houses, are not essential, and are not normally used, in sub-tropical coastal regions of Queensland and Northern New South Wales. However, they are advantageous in maintaining high humidity, particularly in winter; in sub-coastal regions they are a necessity for establishing new grafts.

In coastal regions a shade house with a galvanised pipe frame and covered with 32 to 50% Sarlon shade cloth is quite adequate. It may, however, be necessary to erect a fiberglas wall on the western and southern side to provide some protection from cold winds in winter. Sub-surface drainage must be installed in the ground and the whole floor area covered with several centimetres of crushed blue metal, or washed 19ml (¾ in) gravel Alternatively the floor can be concrete. Naturally, a concrete floor must have sufficient slope for water to drain away quickly following rain or irrigation.

The trees are grown on either wooden or preferably galvanised wire benches about 75 cm above the floor.

There is good evidence to suggest that the root-rot fungi, *Phytophthora cinnamomi,* was first introduced to many orchards in Queensland and Northern New South Wales on nursery trees. Today in order to control this disease a procedure called the Avocado Nursery Voluntary Accreditation Scheme has been introduced and nurserymen wishing to join (and consequently have their name added to an approved list of nurserymen) must comply *with the hygiene standards set out.*

Rootstock seed. Seed is gathered from March to July (fall to mid-winter), or perhaps a little later. The seed, where possible, should be taken from fruit which has been harvested from the tree and handled under hygienic conditions, e.g. kept off the

ground and placed on treated benches. If the seed has been taken out of fruit from the ground, the seed must be hot-water-treated at a temperature of 49° to 50°C for 30 minutes. Rinse seed immediately after treatment in clean, cool chlorinated water (town water) then spread out in the shade to dry (but not on the ground). The seed is then dusted with a fungicide if thought necessary, then planted. Very small and shrivelled seed should be rejected.

Seed should not be taken from immature fruit as this may reduce germination percentage and produce some albino seedlings. Such seedlings do not produce chlorophyll; they live and grow on the food reserves in the seed but if not grafted quickly (soon after emergence) they will die.

If seed is in short supply each seed can be cut in half to give two growing points. This is possible because the avocado seed is polyembryonic. There is more than one bud initial in the seed. The most obvious way to cut the seed in two would be to separate the cotyledons; however when this is done, more often than not the whole embryo stays attached to one of the two cotyledons so you still end up with only one plant.

The correct way is to turn the seed upside down (the flat base uppermost) and to cut the seed across at right angles to the division between the cotyledons. It is important to cut through the centre of the embryo, otherwise you will only have an embryo in one half of the seed and none in the other.

Seed should be planted as soon as possible after extraction from the fruit as the germination will be reduced if the seed is allowed to dry out. If the seed has to be kept for sometime before planting it should be packed in slightly moist peat or sawdust and kept at a temperature of about 43°F (6°C).

Sowing Rootstock Seed. The seed is normally planted in polystyrene or wooden flats filled with either composted or leached sawdust or a pasteurised potting mixture. The seed should be planted with the point either just above, at, or below ground level. The medium must be kept moist, but not too wet, until the shoots emerge.

An alternative method of seed sowing is to sow directly into poly bags, in which the seedling will be grafted; however this results in an uneven stand of plants because the seed will not all germinate at the same time. After the seed sown in flats has a shoot about 7 cm high the seedling is then transplanted into finishing poly bags and transferred to the shade house. The poly finishing bags measure about 14 cm in diameter and 30 cm deep, providing ample space for the development of a tap root.

Marcot Rootstocks. These rootstocks are obtained by girdling

stems on the mother tree about 22 cm back from the shoot tip; the cut in the stem should be 2.5 to 3.5 cm long and the bark must be removed and the cambium scraped to prevent bark from redeveloping. Pack wet peat moss over the girdled area then wrap a square of plastic over the peat and tie at both ends around the stem. Keep the peat moist until the roots are well developed. The marcots can then be removed from the mother tree and planted in poly bags to be grafted when they have made sufficient growth.

The growing media must be open textured and well drained. Some nurserymen use 1 part pine sawdust and 1 part coarse sand; that is, sand to small gravel. Others use 1 part peat, 1 part sand and 1 part polystyrene. After adding nutrients the ingredients are thoroughly mixed and then pasteurised with aerated steam at a temperature of 140°F (60°C) for 30 minutes following which the steam pipe is turned off and the fan is left running until the mixture has cooled.

Rootstock Nutrition. The rootstock should not be starved for nutrients at any time but must be liquid-fed regularly to keep them growing vigorously so that the internodes are long and somewhat rounded. The rootstocks are ready for grafting when they are 35 to 60 cm high and the trunk is 8 to 10 mm in diameter.

Selection of Scionwood. All commercial cultivars now being grown are really clones because each one has been selected from one mother seedling tree. The three most popular ones grown in Queensland and Northern New South Wales are 'Fuerte', 'Sharwill' and 'Hass'.

Scionwood should be cut from tip growth which has matured, that is, hardened off, and the buds in the leaf axils are plump — not thin, but are not bursting into growth. If possible round wood should be selected, not angular, pithy wood. The leaves are cut off immediately the scion is cut from the tree just leaving the stubs of the petioles attached to the scion. Place the prepared scions in a plastic bag and then into an esky. Frozen bricks are placed in the bottom of the esky before leaving home and these and the sides are lined with wet newspaper. The plastic bags are then placed inside with more wet paper over the top.

If absolutely necessary scions can be stored in a refrigerator for a few days at a temperature of 43°F (6°C). They can be stored for longer periods but this should be avoided wherever possible. Before using the scions they may be treated with 5% w/v calcium hypochlorite by dipping for 5 minutes then washing in clean water. Dry before using.

Grafting Gear & Maintenance During Grafting. A grafting

knife, flat on one side and bevelled on the other, should be made of good quality steel and be kept very sharp and clean at all times. The knife should be cleaned regularly during grafting with 70% metholated spirits and a water solution. After dipping the knife in the solution it should be rubbed dry on a clean, freshly laundered cloth. A 1 cm (½") wide strong, plastic grafting tape is used for tying. The one most commonly used is clear but coloured ones are satisfactory.

Although there are several different types of grafts, the two methods most commonly used on avocados are the cleft and whip.

Once the tree has been grafted it is then either placed in a glasshouse where no protection is required over the scion or it is placed in a protected position in a shade house. In this case the scion is sometimes covered with an inverted small plastic bag to retain humidity and consequently reduce transpiration from the scion.

If grafting is done in the field extra protection is advisable such as hessian for shade over the worked tree, and plastic water paint over the scion.

A close watch must be kept on the development of side shoots below the graft and the bulk of these should be removed when the graft has made several centimetres of growth; only the strongest of the buds on the scion should be left.

This remaining shoot is staked and tied with tape and allowed to branch further up away from the union where a stronger framework can be formed. All shoots below the graft must be removed at this stage. The plastic tape is normally cut about 4 weeks after grafting to avoid constriction at the union. Grafted trees should be hardened off in an open sunny position on benches before being sold.