fiber containers, and possibly boxes, are less subject to the pot-bound condition associated with solid-wall containers. (If I sound a little uptight on container-grown trees, let me hasten to add that we grow, buy and sell them at our nursery. Their advantages are obvious and I only hope some genius will solve the interface and root-girdling problems.)

I will briefly cover some techniques for field seedling production. Seed source is obviously vital. If you cannot harvest your own fresh seed you must depend upon reliable collectors or suppliers. There is excellent literature available on the storage, pretreatment and after-ripening requirements of just about any species you might care to propagate. Even so, we run into sticky problems with certain species and have been aided greatly by communicating with our research fellow members, such as Al Fordham, Henry Heit, Harrison Flint and others. Certainly the basic guide in handling seed and securing satisfactory germination is to observe Mother Nature. You won't go far wrong in sowing when she normally disseminates. Of course, if she has arranged to perpetuate the species by having germination strung out over 10 years, you will prefer to fall back on one of the man-devised techniques for securing more prompt and uniform germination.

I have been growing seedlings for some 30 years, but I am happy to see the young fellows in our organization improve on my practices so we can usually count on regular stands of the so-called "two-year" species and other toughies; not that we come through with flying colors on all items we would like to grow. For example, we know how to germinate such desirable natives as paw-paw *(Assimina triloba)* and sassafrass *Sassafrass albidum* var. *molle;* Syn *S. variifolium)* but we have a frustrating time coming up with economic stands. We would like to hear from those who are successful with these species.

MODERATOR HESS: Thank you, Hugh. Our next speaker is Mr. Bruce Usrey who will speak on seedling production in structures.

SEEDLING PRODUCTION IN STRUCTURES

BRUCE USREY

Monrovia Nursery Company

Azusa, California

The seed propagator prior to 1945 believed that the only things that affected seed germination were viability, water, free oxygen, heat, age and maturity of seed, and it was with these things the seed propagator worked with to improve his stand. Once the seeds had been received, treated and sown, the propagator had only heat, and water to work with, as the free oxygen was determined by his media and watering practices.

During this time the propagator used lath or brush structures to protect his seeds from the direct sun and rain. Later he used frames that he filled with manure for heat and covered with glass sash or boards for protection from the elements. Prior to World War II the glass house came into great use for seed propagation and is still used as the primary seed propagating structure. The seeding techniques used in benches or beds prior to World War II has been eliminated by the ease with which flats and pots can be sterilized and moved through the nursery.

Today the germinating medium might be sterilized peatmoss, sphagnum moss, sand, perlite, vermiculite or a combination of these items. It has been found though that two parts peatmoss and one part sand is ideal for 95% of the propagator's requirements. Many growers use a sterilized cracked granite as a top dressing on flats, as it dries rapidly after watering and holds the seeds in place as they germinate, forcing the root into the medium. Seeds are treated for fungus diseases with Thiram or Arasan dusting at planting, or Captan when seeds are germinating. For damping-off disease control, use of cracked granite reduces chances of mycelial growth over the surface as a consequence of its organic-free condition.

Today the seed propagator has eliminated the brush and lath as shade, but uses Saran which diffuses the light and reduces drip damage. This structure is used for slow-to-germinate items (1 to 3 years for cotoneaster) that do not require winter protection or heat for germination.

Today the frames are used where heat is not required but protection from rain is required. The frames are covered when rain comes with either glass sash or polyethylene covers. This protects the seeds and young seedling flats of pines and cedars from becoming water soaked and promoting the damping-off diseases.

Today the modern greenhouse made out of glass, fiberglass or polyethylene with its automatic controls hardly resembles the glasshouse prior to 1940. The best material is still glass with its adaptability for shading and light transmission to fit the varying seasons' requirements, even though fiberglass or polyethylene is considerably cheaper.

In the glasshouse the propagator has control over light, ventilation and heat. Light is controlled by shading on the house, but when more protection is required portable covers of Saran, muslin, newspaper or polyethylene are used to protect the young seedlings from sunburn or rapid drying when seeds are sown on the surface. Light intensities should not be decreased to the point where etiolation of the seedling takes place or disease control becomes impossible due to loss of ultraviolet rays.

During the summer, high temperatures can be as critical as low temperatures during the winter period in damaging the young seedlings and seeds. For this reason ventilation during the summer should be adequate to maintain a temperature that doesn't exceed 90° F with the amount of light transmission desired to prevent burning of the young seedlings. In the industry this is done economically in the East with exhaust fans and in the dryer areas with exhaust fans and evaporative coolers to maintain at least 50% relative humidity. Throughout the year the ventilation system should be used in the morning after watering to provide air circulation in the house and to dry the seed bed surfaces rapidly to prevent the damping-off diseases from having a chance to establish themselves.

Most seed germinating houses contain two or three different heating methods to make the house more flexible for seed propagation. Direct heat from the sun is usually adequate to maintin the desired temperature during the day for most seeds. At night though, you find direct heat being supplied from electric cables or hot water heated benches, keeping the seeds at 70° to 85° F. The rest of the house will be in the range of 65° to 70° F, using indirect heat from hot water or steam in preference to gas heaters which have a drying effect as well as possible damage from leaks or poor ventilation.

In our fern propagation operation, most of the spores are gathered locally off of specimen plants at our nursery or specimens at botanical gardens in the area. The fronds are dried over newspapers where the spore will drop. These spores are not treated with any fungicide or treatment prior to being blown onto sphagnum flats that have been steam sterilized at 180° F for three hours to kill any diseases present. These spores are sown throughout the year and will take 9 months to reach the first transplanting stage, (the sporophyte stage) when they are moved into flats. Disease control is by airing and watering practices, as fungicides have been found to be extremely harmful to the spores. The transplanted ferns grow 6 months in the flats, then they are moved into a 2¼ inch pot for 6 months, and finally shifted into a 3 inch pot for another 6 months before sale or canning. In the fern house we use cooling fans, heavy whitewash, muslin covering and plastic cover to keep a low temperature and a high humidity over the young gametophytes and ferns.

Today the propagator uses a controlled environment structure, one that is economical and practical to control light intensity, temperature, relative humidity, air movement, water quality and nutrient watering.

The propagator of the future will have some of the following advanced things to work with in seed germination:

> The U.S.D.A. Phyto-Engineering Laboratory is now working with automatic surface and sub-irrigation systems that have been found to be beneficial with nutrient watering as

frequently as 8 times per day. This will replace the hand checking and watering of flats used today by most nurseries (1). They have also found that high intensities of light up to 2500 ft-c during a 16-hour day will almost double seedling growth.

The use of carbon dioxide enriched atmosphere has been found to be beneficial for some plants at concentrations of 1,000 to 2,000 parts per million. However, the concentration varies with temperature and the variety being grown and at the present time is impractical for the commercial grower (1).

The use of ultra-violet light to prevent disease on some highly susceptible varieties is impractical now but should be feasible in the near future.

We are now testing the feasibility of negative or neutral atmospheres by changing the positive ionization now found in propagating structures to stimulate seed germination and seedling development.

There is much that we have to learn in the development of a controlled environment house so that the research being done now can be put to economical use. But, the initial investment in research should be off-set by the return from faster and better germination, better disease control, and a strong and vigorous seedling for growing on. I believe the time from sowing to sale can be cut from 50 to 75% by correct utilization of a controlled environment house.

LITERATURE CITED

1. Krizek, D. T., W. A. Bailey, H. H. Klueter, and H. M. Cathey. 1968. Controlled environments for seedling production. *Proc. Int. Plant Prop. Soc.* 18: 273-279.

MODERATOR HESS: Thank you, Bruce. Our next speaker is known to all of you having been on our program many times. He will speak on upgrading *Magnolia virginiana* seedling production. I present to you Mr. Joe McDaniel.

JOE McDANIEL: I wish to acknowledge two of our members who did much of the field testing upon which this paper is based; these are Tom Dodd, Jr., and Don Shadow.