stage if your operation and room permits. We have rooted *Mahonia aquifolium* as well.

The tissue culture of mahonias also has its possibilities, but current multiplication of the shoots is poor and inconsistent. Hopefully this is an obstacle we can overcome in the near future.

VOICE: Can you comment on problems with looper worm in the production of mahonias?

DENNIS CONNER: It is a problem — not so much on cuttings as with seedlings. But at Monrovia Nursery we are generally on a preventative program to keep these problems from ever developing.

VOICE: When do you start fertilizing your mahonias?

DENNIS CONNER: We normally do not fertilize any cuttings until after they have developed a root system. But for mahonias, they do not go through an acclimating period before potting. They go from the mist bed right to the potting shed. They tend to go backwards if you hold them too long. Once they get in the potting soil they receive fertilizers, also subsequently during irrigation they get fertilizers. The same with seedlings — they are not fertilized until potting.

ARCTOSTAPHYLOS PROPAGATION

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Manzanitas, *Arctostaphylos* species, have been propagated at the Santa Barbara Botanic Garden for several decades. Over the years various treatments have been tried to improve seed germination. None has been very satisfactory. The two methods that have repeatedly given some or even good seed germination are the use of fire and acid.

The seeds of this genus have thick, impermeable nut-like seed coats and seeds of many species also exhibit internal dormancy.

For the fire treatment, after the seed is sown and covered, an additional layer of 3 to 4 in. of dry pine needles or excelsior is added and ignited. When the resulting hot flash fire is finished and the seed bed has cooled, it is watered thoroughly. This treatment should be done outside well away from any

combustible material. It should also be done in the early fall, and the seeded containers left outdoors for germination so that if internal dormancy is a factor its rectification will occur naturally during the winter.

The ripe fruit of the manzanita is like an orange in that it is composed of separate locules. With some species these locules or sections separate into individual nutlets or chips that do not always contain embryos. In other species, two or more nutlets remain fused together, or all the locules remain fused together.

The concentrated sulfuric acid treatment is painstaking as the length of time the seed needs to be soaked in the acid must be determined empirically with each batch of seed. Also, single nutlets, fused groups, and whole fruit may need different amounts of time in the acid. While soaking in the acid (at room temperature) the seed should be stirred occasionally with a glass rod. The acid bath must be continued long enough to almost, but not quite, burn through the seed coat to the embryo.

After the acid treatment (which is done in early summer), the seed must be washed thoroughly several times to remove all the acid and then sown out of doors. Germination should occur by the following spring. A word of warning — concentrated sulfuric acid is very caustic and is dangerous to use.

Specific recommendations for two species indicate the problems involved: *A. glauca*, bigberry manzanita, requires 6 to 15 hrs. in concentrated sulfuric acid (2). *A. uva-ursi*, bearberry, needs 3 to 6 hours in concentrated sulfuric acid, then 2 to 4 months warm (8 hrs. at 65°F, then 16 hrs. at 86°F), followed by 2 to 3 months cold (35° to 40°F) stratification (2), or 6 hours acid and 2 months each of warm and then cold stratification (1). If the acid-only treatment is done in early summer and the seeded container is left outdoors, germination can be expected by spring. In some areas of southern California with relatively warm winters, artificial cold stratification may be necessary.

Small seedlings do not tolerate root disturbance very well, and the mortality rate from spotting-off may be high. This spotting-off is most successful after the second to fourth pair of true leaves has appeared.

In this author's opinion vegetative propagation is much easier (more practical) than any known seed germination technique and, of course, the only way to preserve clonal forms.

Asexual propagation of *Arctostaphylos* presents no unusual problems where cuttings are being taken from cultivated plants. At the Santa Barbara Botanic Garden we prefer to take

cuttings between the last half of November and the first half of February. This enables us to produce gallon can plants of sufficient size to plant-out or sell by fall. Also, cuttings produce heavier caliper roots when rooted in the cool part of the year. We usually use 3 to 4 in. tip cuttings from garden plants. The cuttings are submerged in a 5 to 10% household bleach; then the basal ½ to 1 in. is dipped in a root-inducing hormone. Hormex (60 sec. dip) seems to induce quicker rooting than Rootone.

The cuttings are stuck in perlite (Sponge Rok), medium grade, and peatmoss (2:1) or vermiculite and perlite (1:1), using medium grade for both components. The cuttings are rooted with bottom heat (70°F.) and intermittent mist. our mist unit is in a lathhouse, and an artificial electronic leaf works well to control the mist. Our intermittent mist unit uses deionized water, and no fertilizer is added during the rooting period.

The cuttings are checked for rooting every two weeks after the first month. The rooted ones are potted, usually in 3 in. pots; unrooted cuttings are returned to the mist unit. Once potted the rooted cuttings are hardened-off over a two week period in the hot bed (70°F.) They are then watered with $Ca(NO_3)_2$ and placed in a glasshouse or lathhouse depending on the season. In winter the outside temperature is too cold to promote much new growth.

Our potting mix is a U.C. soil-less mix of 1:1:1, #30 crystal white (washed) sand, peatmoss, perlite (medium grade) and an inorganic fertilizer component. As soon as root growth is sufficient, the plants in liners are transplanted to 1 gal. cans. The can yard, with a concrete floor, has 30% Saran shade, which is insufficient to cause any "stretching," yet is adequate to prevent the plants' root systems from overheating during periodic heat waves. The canning mix is also artificial: builders sand, peatmoss, and fir shavings (not redwood) at a ratio of 8:2:6. A fertilizer component is also added. None of our media is sterilized.

Among those species and clones which are commonly grown every year at the Santa Barbara Botanic Garden, the percentage of cuttings that root is often 100% or nearly so. This long-term success persists even when cuttings are taken from the same stock plants. In one case the same stock plant has been used for 17 consecutive years with no decrease in rooting percentage.

Cuttings from plants in the wild, particularly those with pubescent or hairy stems, may root very poorly and then only sporadically over a period of up to five months.

Rooting time normally starts in as little as 30 days and is

usually finished in 60 to 75 days. It is not unusual to be canning the first rooted of a particular batch, while the slower ones of the same batch are still rooting. In some cases we make enough cuttings so that 60 to 80% will have rooted over a two-week period, then the balance are discarded.

During the past several years a disease problem has developed in the nursery, which is limited to the manzanita — mainly to those in gallon cans. Random leaves and twigs die and turn brown. The dead leaves do not drop off the plant. When the main stem is attacked at the surface of the canning mix, the whole plant dies. The pathogen involved is *Botryosphaeria*, which is common among various manzanitas of our area. As a result, last year we started using a plant drench consisting of 0.3 ml of Subdue and 0.76 gm of benomyl per gallon of water. This is applied once a month as a preventive spray, starting with the first canning.

LITERATURE CITED

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2. USDA Forest Service. 1974. Seeds of Woody Plants in the United States. USDA Agricultural Handbook No. 450. U.S. Government Printing Office, Washington, D.C.

VOICE: Dara, when you treat your manzanita seed with fire to aid germination — are they cleaned first?

DARA EMERY: The seeds are cleaned, sown on the medium, covered lightly, then the excelsior is added and burned. We start with dry seed for the burning.

VOICE: What level of seed germination do you get with *Arctostaphylos*?

DARA EMERY: Germination rates are still very low — due particularly to seed coat dormancy — despite all our treatments.

HUDSON HARTMANN: Have you tried the hot water treatment to overcome your seed coat problems?

DARA EMERY: No, I haven't. *Arctostaphylos* seed has such a thick seed covering that I doubt if it would work. As I remember, the hot water treatment works best on seeds having a thin seed coat.

HUDSON HARTMANN: It may be worth a try. It is simple to use. Just dump the seeds into a large container (4 to 5 times or more the seed volume) of boiling water, turn off the heat, and allow the seeds to soak in the gradually cooling water for 24 hrs.