under full sun. The mist is set 3 sec. every 3 min. After rooting, the trays are transferred to a plastic greenhouse to grow the following spring.

We have found that these young rooted cuttings in trays need to be kept in a heated plastic greenhouse the first winter with no lower night temperatures than 35°F. Daytime temperatures may go up to 70°F on sunny days. This environment keeps the cuttings in good condition. They seem to be much slower to break in spring than most plants.

The rooted cuttings are transplanted to fertile liner-growing beds in May each year. *Clethra* is a low-growing shrub compared to some others like forsythia. We like to see it at least one foot or taller to transplant to the field the following spring. These plants should grow in the field for two summers before they are sold.

PROPAGATION OF *VIBURNUM CARLESII* HYBRIDS

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Viburnum carlesii cultivars and hybrids are desirable for their fragrant flowers, excellent foliage, lack of serious pests, hardiness, and some fall color. The U.S. National Arboretum has introduced several interspecific hybrids that show promise.

We propagate several hybrids of *Viburnum carlesii* by cuttings. *Viburnum carlesii* 'Compactum', *Viburnum* × *juddii* (*V. bitchiuense* × *V. carlesii*), *Viburnum* × *carlcephalum* (*V. carlesii* × *V. macrocephalum* var. *keteleerii*), *Viburnum* 'Cayuga' (*V. carlesii* × *V. carcelephalum*), *Viburnum burkwoodii* (*V. carlesii* × *V. utile*), *Viburnum* × *burkwoodii* 'Mohawk' (*V.* × *V. carlesii*), *Viburnum* 'Chesapeake' (*V.* Cayuga; × *V. utile*), and *Viburnum* 'Eskimo' (*V.* 'Cayuga' × *V. utile*) are among those we produce.

Description of ground beds and equipment. We propagate in 4- × 48-ft. ground beds bordered by crossties or treated 6-in. wood poles. The rooting medium is Emory soil, a fine sandy loam, which has been amended over the years with sand and organic matter. I like this medium, as the clay colloidal material improves the cation exchange capacity and contains nutrients not available in artificial soils. We fumigate with methyl bromide at a rate of 1½ lb./100 ft.^{2}

We cover the beds and support the polyethylene with 6-

gauge, 6-in. concrete reinforcing wire. We use either a 2-mil clear polyethylene, (which we cover with a 48% shade fabric), or a 3-mil white polyethylene, which has been manufactured to our specifications to transmit approximately 50% light. We have found the white poly to be satisfactory except in late summer when the sun scorches the plants through the ventilation holes.

We have constant water pressure to a solenoid valve connected to a wiring system controlled by time clocks. We have recently changed from ½-in. galvanized steel mist lines with nozzles every 46 in. to ¾-in., 100-PSI black poly pipe with spaghetti tubes leading to our nozzles. These new lines are easier to work and afford more flexibility as to nozzle placement than the galvanized steel pipes. We use a Spraying Systems nozzle with a D-1 orifice. We have modified the nozzle with a ⅛-in. stainless-steel welding rod to deflect the spray.

Taking cuttings. Cuttings of *Viburnum carlesii* hybrids are taken when the new growth hardens off enough so that it breaks crisply when bent. It is one of the first species we stick, usually in late May or early June. We stick a second crop as late as August or early September. We plan to hold these cuttings an additional year and sell as a two-year bed-grown plant.

We take our cuttings in the mornings when moisture stress is not a problem. We keep the cuttings turgid by keeping them moist and shaded at all times. In the field we keep the cuttings moist in 5-gal. buckets with wet burlap or cloth. We then put them in water in a cattle-watering trough or a 30-gal. garbage can in a pick-up truck and transport them back to the nursery. We do not like to keep the cuttings submerged in water for long. At the nursery we remove the cuttings to a structure that enables us to mist the cuttings constantly until they are stuck in the beds.

We leave 3 to 4 leaves on each cutting and do not cut the leaves. We bundle the cuttings in the field into groups of 25 to count production for our piece-rate system.

Sticking cuttings. We finish taking cuttings by noon and stick each morning's production in the afternoon of the same day. Cuttings are dipped in a solution of 2,500 ppm IBA and methyl alcohol. Production is counted at this step. We use a portable shade structure to keep the plants from wilting until we get the frames in place and the bed covered with polyethylene. At this stage the plants are misted as needed to provide as close as possible to 100% humidity on the leaf surface and still maintain a well-drained soil condition.

As rooting commences, the misting schedule is reduced

gradually and more cuts for ventilation are made in the polyethylene until the plants are hardened off or weaned. At this point all the polyethylene is removed. For a few days we shade and mist the plants every 30 min. After a few days we remove the intermittent mist, but leave the shade in place, and hand water 2 or 3 times a day. A few days later we remove the shade and hand water as needed. The entire process takes 6 to 8 weeks.

Fertilization. We test our soil with the Simplex system. We choose our fertilizer based on test results, paying particular attention to imbalances that may cause problems. During the growing season we monitor the soluble-salt level closely and fertilize so as to keep the soluble-salt level high yet below toxic levels. Previously we used liquid fertilizer with a venturi-type injector. We supplemented our liquid feed with various granular fertilizers as needed. This year we incorporated Osmocote 18-6-12 at a rate of 4 lb./100 ft.^{2} into the top 6 inches of soil.

Hardening off for winter. Normal leaf drop indicates that the plants have built up their carbohydrate reserve in the root system naturally and are becoming dormant for the winter. At that time we cover the beds with microfoam over the wire frames and cover the microfoam with polyethylene. We nail the polyethylene to the cross-ties with wooden strips and seal the edges with soil. Prior to covering we water the plants well and spray with a fungicide. The purpose of winter protection *is not to keep the plants warm but to protect from rapid* temperature fluctuations.

Harvesting. We dig the plants before they break dormancy but as late as we think is safe, so as to keep the plants as fresh as possible. We pack in polyethylene-lined and wax-lined boxes, with the roots wrapped in spaghnum moss and the tops separated with excelsior. We ship via United Parcel Service.

Handling bare-root deciduous viburnums. After deciduous viburnums are packed, they must be kept cold enough to prevent them from breaking dormancy. We do this by keeping them at 34 to 36°F. in a cold storage facility. Deciduous viburnums transplant well anytime during the late winter or early spring while they are still dormant. They should be placed under conditions where they can be kept cold but nor severely frozen until they warm up gradually and naturally as spring arrives. Putting deciduous viburnum liners suddenly into a warm greenhouse in late winter or early spring often gives poor results simply because the leaves appear almost immediately, before the roots have had time to develop.

Viburnums require a large number of hours of low tem-

perature, 40°F. or below, during their dormant season if they are to be healthy and grow well the next year. Deciduous viburnums respond well to fertilizer after they become established in the soil. They should be irrigated frequently, but they also require good drainage. It is advisable to dip the root system in a mud slurry or other wetting agent to keep the roots from drying while transplanting.

PROPAGATION OF *QUERCUS VIRGINIANA* CUTTINGS

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Traditionally live oak (*Quercus virginiana*) trees are propagated by seed. But oaks are wind-pollinated and are heterozygous by nature, so they often exhibit genetic variation in a great variety of characteristics, only some of which are visible.

Obvious differences can be found among individual live oaks in branching habit, height, leaf shape, even color. It is likely that other sources of variations may occur, such as in susceptibility to insects and diseases, response to fertility, vigor, and winter hardiness. Attaining the ability to select outstanding trees and successfully propagate them for their inheritable characteristics would represent a significant contribution to the landscape industry. Development of practical means of vegetative propagation is an important step toward that end.

Propagation by cuttings is generally regarded as the most important method of vegetatively increasing both deciduous and evergreen species. It is a means by which the parent plant is usually reproduced exactly with no genetic change (6). Yet propagating trees by cuttings often is more easily described than performed due to many factors one of which is juvenility.

Juvenility and rooting. It is not juvenility that causes concern to plant propagators. Instead it is the loss of juvenility that is coincident with the onset of the *adult* or *mature* phase in plant development. This physiological change typically occurs when flowers first begin to appear and the plant gradually shifts from a strictly vegetative to a reproductive condition. During this transformation, rooting of cuttings becomes more difficult in many woody plants. As a plant ages, it generally becomes more physiologically mature. Oak species vary widely in how old they must be before beginning flower produc-