were incorporated. In comparison with control plants, mycorrhizal geraniums had greater plant growth, flower development, and increased internal nitrogen levels. Mycorrhizal geraniums also recovered from water stress more rapidly, which is an important factor in the diverse and often stressful climates of Texas.

Current research is designed to investigate the potential of utilizing mycorrhizae in the production systems of field roses, oaks, pines, and other Texas nursery crops.

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RHODODENDRON PROPAGATION — NO MIST WITH BOTTOM HEAT

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Since 1975, when Roadview Farm Nursery was established, rhododendron propagation has normally started in September. At this time the summer growth on the container-grown plants has matured sufficiently so that cuttings may be taken. The cuttings are stripped of the lower leaves, trimmed to a uniform length and double wounded. Leaf surface area is not reduced. Cuttings are then soaked in a Captan-Benlate solution. They are stuck in trays to give 1½-in. spacing. In the early years of the nursery the cuttings were stuck in 6-in. deep peat and perlite beds raised 3 ft. off the ground. The beds were in double poly propagation houses. Warm air from counter-flow oil-fired furnaces was blown under the benches, which were enclosed with plastic to contain the heat. Mist regulated by time clocks was applied to the cuttings until rooting was well developed. We found that the hot air furnaces were running constantly on cold nights and, with rising fuel oil costs, a more efficient system had to be installed.

In 1979, in an attempt to reduce heating costs, we switched from hot air furnances to hot water boilers to heat two of our three propagation houses. After considerable discussion it was decided to run 1-in. plastic pipe in loops in the ground to heat the cuttings. To increase the efficiency of the

system we first laid 1-in. thick styrofoam boards beneath the hot water pipes to prevent the loss of heat to the ground. Next we placed 3 in. of crush-and-run gravel over the hot water pipes. The plastic pipe was spaced 6 in. apart and tied to a wire screen to keep the flexible plastic pipe stationary. The gravel was used to transfer the heat evenly to the propagation media and also to act as storage of the heat released from the hot water pipes. The cuttings were then stuck in trays containing 60% peat and 40% perlite and placed on top of the gravel. Thermostats placed in the trays keep the media at a temperature from 60° to 72°F. We estimated that fuel costs were reduced 50% by switching to hot water to heat the propagation beds. We have had no trouble with the durability of the plastic pipe.

In December, 1979, we decided to try placing a sheet of clear plastic over the propagation beds to confine the heat to the beds to save further on heating costs. Using the pipe frames that originally held the hot-air benches, we constructed frames of 1-in. conduit over which we could drape 4 mil clear plastic. The plastic was stapled to the outside edge of the bed. The inside edge of the plastic was left loose so that it could be raised to release excess heat on warm days. This also allowed for the application of fungicides to the cuttings. Condensation quickly formed on the inside of the tents covering the beds, evidence that the humidity was sufficient to allow us to turn off the mist system.

With this system we have been able to maintain a 70°F soil temperature with a minimum of heat even on the coldest nights. At 7 a.m. on December 22, 1980, the outside air temperature was 11°F. Within the propagation house the air temperature was 30°F, and frost had formed on the inside of the double layer of 6-mil plastic. Within the tents the air temperature was 48°F and the soil temperature was kept at 70°F.

We now are sticking cuttings beginning in July. We then remove rooted ones and refill the benches. We may continue to stick cuttings until January. We have normally taken our cuttings in the fall so we are not as experienced with judging maturity of the wood in the summer. It is changing rapidly at that time, making it more difficult to select cuttings that are in the proper stage of growth.

In conclusion, by using hot water to heat the propagation media, and by storing the heat in a gravel bed enclosed by plastic, we have been able to reduce heating sharply. With the tents in place humidity is increased and the loss of plant nutrients by leaching action of mist is reduced. Finally, we

believe that rooting percentages have increased and a better rooted cutting has been produced.

PROPAGATION UNDER POLY FILM — NO MIST

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I had the pleasure of going to England, Belgium, and Holland on the 1980 IPPS tour. One of the most impressive things I saw was the way they propagated with poly lying on the cutitngs in the frames and benches. I asked why they had no mist, and the reply was, "What we do works."

Sealed or closed propagating structures are not new to IPPS members. The Nearing frame has been mentioned a number of times in the Proceedings. It was noted for use in rooting difficult-to-root material. It emphasized the use of cool north light and a good moisture reserve built in. The air space around the cutting was small and sealed. I felt that the conditions were similar to what the Dutch were doing. I made up my mind then that when I got home I would try their system. The simplicity of the idea seemed so appealing that I ordered a capillary mat and installed it on the floor of a heated house. The floor has porous concrete with hot water pipes below the surface, which produce good steady bottom heat. It was January when we made a crop of broad-leaved cuttings. We made an assortment of *Ilex crenata*, *I. cornuta* and others in flats and arranged them on the mat. They were watered well and then covered with a thin poly cover lying directly on the cuttings. Prior to sticking the cuttings they were treated with 0.25% IBA in alcohol. We used the quick-dip method, and bottom heat was adjusted to about 74°F.

I have never seen quicker or better roots form on these species. On most of the *Ilex crenata* cuttings roots were becoming well formed in two weeks. They continued to develop and even grew out the bottom of the flats. I became very enthusiastic and removed the plastic cover as soon as the roots had gotten a good start. A problem did develop at this point which turned up when checking the cuttings. I found some browning in the *I. crenata* 'Helleri' flats caused by a soft root rot identified as *Pythium*. A drench program using Subdue (metalaxyl-CIBA-GEIGY) seemed to do a good job in controlling this fungus. The disease had spread with an incline in the floor and the capillary mat apeared to be a good conveyer. The excellent roots on the 'Helleri' cuttings had grown out of the