alternatives to pine bark if its future price makes it uneconomical to use.

A SYSTEM OF WATER TABLE CONTROL FOR SUBSURFACE DRAINAGE AND IRRIGATION

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Agriculture is a risky business. The extremes of weather are, perhaps, the worst of the many hazards faced. Most weather-related hazards are uncontrollable. However, any action that can be taken to alleviate the extremes helps to reduce the risk and increase crop production.

Our initial problem was one of drainage. While attempting to solve this problem, we devised a system of water table control, with the help of the Soil Conservation Service, that presently serves 108 acres. This system has provided us with drainage as well as protection from drought. It has enabled us to transplant successfully during the growing season. A water table control system with modifications to fit other situations may be of benefit.

We own two farms that are located just east of the city of Orangeburg, South Carolina, in an area that is commonly known as the "Flat Woods." The nursery is located on the farm nearest to town. The other we refer to as the "Lower Farm". We had a serious drainage problem during periods of excessive rainfall. For years we had accepted the fact that these farms were low and wet.

A survey by the Soil Conservation Service revealed that we could gain three feet of additional fall by deepening and enlarging about 1½ miles of an old inadequate outfall canal on our lower farm. This enabled us to deepen our lateral ditches sufficiently to permit the installation of several miles of agricultural tile (one foot lengths of six-inch clay pipe) for subsurface drainage. We were amazed by the efficiency with which this system removed excess water. (See Figure 1.)

We requested a survey of the nursery farm to see if we might have additional fall here also. We gained five feet of fall by deepening and enlarging just one mile of our old outfall canal. We were not low — just flat!

We became completely carried away with deepening our old lateral ditches to take advantage of every inch of our new-

WATER TABLE CONTROL PLAN
FOR
SHADY GROVE NURSERY

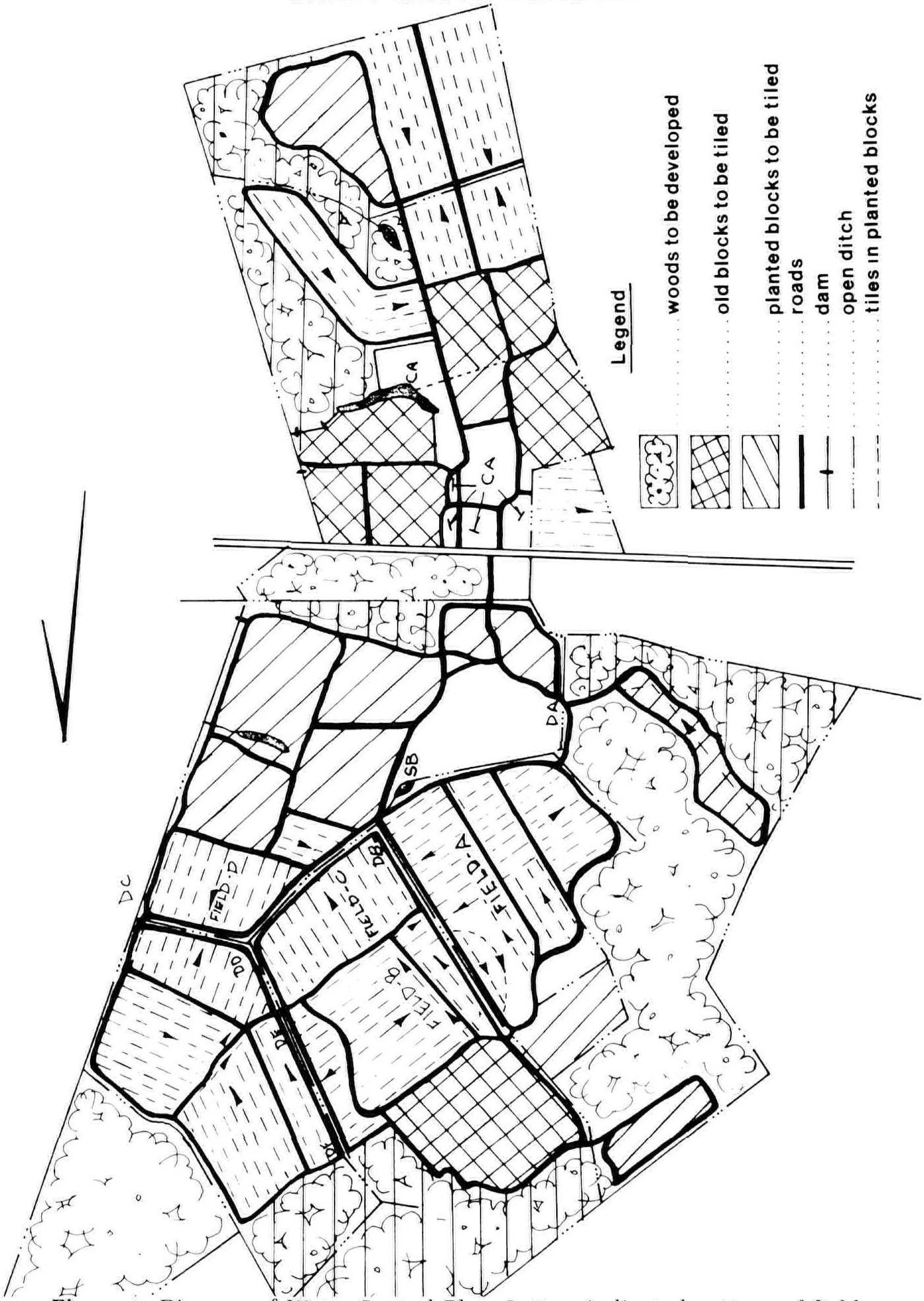

Figure 1. Diagram of Water Control Plan. Letters indicate locations of fields, dams, and pumps described in text.

found fall. In the midst of all this digging Lewis Howell of Newbern, North Carolina, stopped by to visit. Lewis urged us to construct control dams in our laterals, as had been done at Greenbriar Farms, so that we could release water only as required. We had an ideal situation for this type installation with the canal and highway bisecting the narrow center of our farm. Most of our water would enter the canal from two laterals on our lower property line. We followed Lewis' advice and constructed dams with flashboard risers near the mouths of these laterals.

Several dry years followed and the dams alone were inadequate to maintain the water table. To take care of a newly-planted nursery field, we were forced to resort to portable overhead irrigation with all the inherent agony. There had to be a better way to distribute water during periods of inadequate rainfall.

One day after an extremely heavy rain, while watching the rapid removal of excess water by the drain tile on our Lower Farm, the possible solution became apparent. If tile was able to remove water from our soil so efficiently, why could it not be installed in a manner that would permit the same system to return water during periods of inadequate rainfall?

After much discussion and study, a trial plan was finalized for a 6 acre block. Following this plan, six inch agricultural drain tile was installed in parallel lines 80 feet apart at a depth of 2½ feet. The grade was 0.12 feet of fall per 100 feet to insure self-cleaning. Five inches of crushed stone were placed on the top of the tile to serve as a filter. The remainder of each ditch was backfilled with the soil that had been excavated. A 10 foot section of rigid pipe was installed on the discharge end of each line in lieu of constructing a head wall. These lines discharged into an open header ditch that had a dam with a flashboard riser located just below the last tile drain outlet. An open pit-type reservoir was dug in a low spot nearby as a source of water.

All of this construction was expensive, but we were sure that since it served the dual purpose of rapid drainage and irrigation it was financially practical.

We had just completed all of our installation when we went into a prolonged period of heavy rain. Our tile system removed all of this excess of water at a rate even exceeding expectations, and we were able to complete our lining out on schedule.

We enjoyed the success of the drainage function so much that we made a near fatal mistake. We permitted our field to drain completely before we added boards in our riser to limit the flow of water. As so often happens in our area, we went from a period of excessive rain directly to a drought situation.

Our system was designed on the premise that we would add boards to catch spring rains and hold our water table at an acceptable level, which was yet to be determined. Our source of water was adequate only to supplement this impounded water--it could not bring us back from bone dry. Fortunately, we were able to pipe sufficient additional water from our main reservoir. The tile did a beautiful job of distributing moisture through the field. This saved our crop.

We learned a lot from this little field: (1) it is feasible to install a system of tile for the dual purpose of subsurface drainage and irrigation, (2) we needed to incorporate grading for surface run-off of excess water, (3) we had much to learn about the management of such a system.

After our drought experience of the first summer, we overreacted the second summer by holding the water level in the ditch so high that we nearly drowned our crop. We then realized that the proper management procedure would be to maintain the water table at a depth that would permit only optimum capillary moisture to enter the root zone of the trees. This gave us excellent performance and has become our guide for growing season water management through the years.

We were elated when we began to realize fully the potential of such a system of water table control. Our deep outfall canal had put us in the position of turning the flat topography that had been so detrimental through the years into one of our finest assests.

This pilot field was installed in 1960. Its successful operation for several years had a big influence on the decision we made after pausing to take a good hard look at the trend of the nursery business in the U.S. Southeast. It was moving rapidly toward the production of small stock in containers for the mass market. Our main interest was the production of materials for the landscape professional market, which had been generated while we were landscape contractors. This market was being conspicuously neglected. We evaluated our assets and found that our labor, location, land and potential system of water table control would enable us to specialize in the production of specimen-size landscape materials.

We had learned from our pilot field that even with closely spaced tile for subdrainage, grading for surface drainage would be very beneficial. The Soil Conservation Service laid out the entire field in 100 foot grids, and we graded sufficiently for all surface water to be able to move out of the field.

Since perforated plastic tile has come on the market, we have used it exclusively because of its lower cost and ease of handling. We experimented with laying tile ourselves with our Davis 300 trencher and found this was not practical. Since then we have contracted all tile installation.

We realized that it might become necessary for us to resort to mechanical spade digging in the future, so we increased our row width to 8 feet with 4 foot spacing in the row. We were aware that 8 feet would probably not permit us to dig selectively down each row so we decided to plant blocks of eight rows of the same plant material and skip every ninth row. This would give us a 16 foot space between blocks that we would utilize to dig into the sides of the blocks.

Our plan was to start marketing trees at 2 inch caliper and selectively thin to provide wider spacing for growing to larger sizes. If we continued to hand-dig, the skip row would serve as a pick-up road for our crane truck which could easily remove trees from the center of each 8 row block.

We feared that activity in the skip row might cause sufficient compaction to limit the lateral movement of water from the tiles. To alleviate this potential problem, we installed our tile in the middle of each eight-row block. The distance between the lines was 72 feet. We decided that a depth of 3 to 4 feet would be better than the previously used 2½ feet as it would allow us to lower the water table farther when digging large trees. It would also permit us to maintain a minimum of 4 inches of free water above the tile during the growing season, which would protect it from possible tree root penetration.

We were rapidly approaching the point that we had to do something about a larger and more dependable source of water. The most logical solution was to dig a deep well. No data was available to help us size the well. Our best calculation was that 400 gallons per minute should take care of the 120 acres of land with the system we were installing. We were advised that a 10 inch well should give us about this volume. We were elated when the well initially produced 450 gallons per minute and is now producing close to 500 gallons per minute. This well is located so that it can supply both sides of the highway with a minimum of pumping. To serve the north side of the highway, the water free-flows in a ditch under the highway into a large sump. From this sump two pumps lift the water approximately 7 feet over a dam, the main pump is a 4 inch 5 horsepower with a 400 gallons per minute capacity. The other is a sump pump with 150 gallons per minute capacity. It operates automatically as the water level fluctuates.

This dam is equipped with a flashboard riser and controls the water table in the western half of the 20 acre field (A). Surplus water flows in an open ditch to a sump (SB) from which it is pumped by a 5 horsepower pump above a second dam (DB). This dam is also equipped with a flashboard riser. The lift is only about 18 inches to a ditch that feeds the northern half of the 20 acre field. It is also located to supply the high ground portion of the field B that we developed in 1973.

Below dam B are approximately 20 acres of land, the elevation of which averages 2 feet below the high ground of fields A and B. We dug our feeder ditch through the center of this lower area and constructed a dam (DC), with a flashboard riser before the ditch entered the large lateral canal on our lower property line. Water flows over the adjustable boards of dam B to supply this feeder ditch. Dam C holds this water at about 2 feet below the level of the water at dam B.

We installed the eastern half of field D in 1972. To our delight the Soil Conservation Service changed their recommendation for filters from rock to sawdust. We were assured that a 2 foot by 2 foot plug of sawdust sealed underground would last indefinitely. We were not hard to sell because the cost of rock had gone out of sight.

Heavy digging of orders in the winter and spring of 1972-73 prevented our lining out this field until May. We were able to irrigate this newly planted stock with water from below, and we had a beautiful result.

The big jump in the cost of all petroleum products nearly made us back out of the construction in fields B and C, scheduled for 1973. We closely evaluated and decided to make the installation. We went through the same agony of indecision in 1974. This time it was even worse because we were experiencing a slump in sales. We were scheduled to install 14,000 feet of pipe in the field north of dams C, D, E, and F that year; and the total cost appeared prohibitive. When the total cost was broken down on a per tree basis, it amounted to only 69 cents. With this low cost per tree, there was no way we could justify not making the installation. The increases in growth we have obtained in this field the last two drought summers have repaid the original 69 cents many times.

The major portion of our trees go on jobs with rigid construction schedules. Seldom do these schedules consider that trees may have a preference as to the time of year they are transplanted. Twelve to fifteen years ago we began finding ourselves confronted with more and more jobs requiring summer planting. We were forced to work out a technique to accomplish this successfully. Our procedure is simple and very safe as long as we strictly adhere to the following steps:

(1) Dig only trees in a turgid state with reasonably mature wood. The trees in our water-table-controlled areas are turgid during the growing season.
(2) Spray with an antidesiccant prior to digging.
(3) Thin out trees.
(4) Hold in a hardening-off area (light shade and light water on foliage) for a week to ten days.
(5) Spray again with an antidesiccant before loading.
(6) Haul only at night, covered, and try to have all trees planted no later than 10 a.m.

Water table control does have certain disadvantages:

(1) Initial investment is relatively high. Present total cost is approximately $600.00 per acre. Open ditch costs are not included.
   A. Tile installation costs approximately $360 per acre.
   B. Twelve dams and flashboard risers each cost approximately $650. Per acre share is approximately $72.00.
   C. Well and pump cost is approximately $15,000. Per acre share is approximately $140.
   D. Distribution pumps and installation cost approximately $3,800. Per acre share is approximately $35.
(2) There is some water loss due to seepage from our transmission canal.
(3) The system cannot be used to apply fertilizer and pesticides.

However, we believe these are outweighed by the advantages:

(1) Operating cost is low because of lifting water only a few feet. During what is said to be the worst drought in our county since 1924, the cost of electricity was $1,650 for pumping from January 1 to December 1. Total cost to operate per acre during this period was approximately $15.28.
(2) Distribution of water is highly efficient. The only loss to evaporation is from the surface of the ditches.
(3) There is minimum loss to seepage because distribution ditches are located between fields.
(4) Optimum moisture is maintained right where it is needed in the root zone of the trees. This encourages a compact fibrous root system and a uniform rate of top growth.
(5) The field surface is not muddied nor does weed seed germinate.

(6) The system operates 24 hours a day, seven days a week, with a minimum of monitoring. Ours ran continuously during the entire drought period with only two minor breakdowns.

(7) In the event of a big rain, it takes only about 20 minutes to switch off the pumps and remove enough boards to reverse the entire system to drain.

(8) Winter drainage is almost as valuable as summer irrigation. At the end of the growing season, we remove all boards from the risers and drop the water table as low as possible. This gives us a head start on wet weather. Our tile removes water so efficiently after each rain that we can usually get back in the field within 24 to 36 hours and resume digging operations.

This type system is more quickly responsive in soil types such as Lynchburg, Goldsboro, and Raines. These have some sand mixed with clay in the subsoil and permit rather rapid movement of both free and capillary water. We do have some Coxville and Grady (both rather heavy clays) included in our control area. These types will work, but time to adjust back to optimum is much longer. There are clays that will not permit tile to drain. In these soils, our system would not work. If tile cannot take water out, it cannot put it back.

A fairly level topography is desirable. Even with our flat land, we had to do a surprising amount of grade changing. The more uniform the depth of the water table can be maintained below the surface of the field, the better the results. We have been able to reduce field surface grade changing to a minimum by the use of dams with flashboard risers to control the water table to fit fields of different surface elevations.

We have found the optimum depth for us to maintain our water table during the growing season is within the range of 2 to 3 feet below ground level. Free water at this depth prevents deep rooting and promotes a fine fibrous root system. We are as interested in what we are growing below the ground as on top.

This water table control system has solved many of our problems. It has provided us with drainage and irrigation. It has extended our production season. And it has enabled us to produce a superior product.

QUESTIONS FOLLOWING GROWING MEDIA FORUM

BILL COLBURN: Question for Richard Van Landingham. Do you root your azaleas in the pine bark mix? As I understand it, you do grow them in that mix.

RICHARD VAN LANDINGHAM: We do root them in that mix. Almost all of our propagation is also done in this medium. For one or two species we add a small amount of perlite, but for 90 percent of our plants we use the basic mix.

CHARLES PARKERSON: Question for Richard Van Landingham. What is the air space in that mix?

RICHARD VAN LANDINGHAM: I do not know exactly. We had talked about removing the shale because we felt we did not need it. However, we decided that the shale was important since it does not change or decompose as the bark does. We would like about 20 percent air space.

CHARLES PARKERSON: Question for John Brailsford. Is the soil type critical for successful subsurface irrigation?

JOHN BRAILSFORD: The reaction time varies considerably with soils, but we overcome this by maintaining a uniform water table.

BOB LOGNER: Question for Carl Bauer. Do you wound your dogwood liners on both sides of your cuttings or just one side?

CARL BAUER: No, we wound only one side.

TED GOREAU: Question for Ed Kinsey. Do you use anything higher than 0.8% IBA?

ED KINSEY: No. I think that lately we have been reducing the amount. Most of the plants that root at higher concentrations will root just as well at a lower one.

NICK HAND: Question for Harry Hopperton. I would like to know what ties you used for your chip budding and what rate your budders can bud.

HARRY HOPPERTON: We use a plastic tie for our chip budding, but rubber works equally well. Our top budder, now 77, has done 3500 per day. Now I would say he is down to 1500 to 2000 a day.

GREG AMMON: Question for Ed Kinsey: What is the medium that you use on dwarf conifers?

ED KINSEY: We are using pine bark, shale, and sand in a 4:1:1 ratio, which is primarily what we are using for our other plants. We are not adding Osmocote in the mix but are just liquid feeding with the injector system.

HARRY HOPPERTON: Question for Carl Bauer. What herbicides are you using?

CARL BAUER: On our dogwoods, we are using Surflan.

DICK AMMON: Question for Ed Kinsey. What application rate of Ronstar do you use?

ED KINSEY: 4 lbs active ingredient per acre.

CARL BAUER: Question for Harry Hopperton: When do you cut trees back to encourage development of a head?

HARRY HOPPERTON: We do not cut them back. Most of our customers want a 10 foot trunk.

JAKE TINGA: Question for Harry Hoitink. Would you comment on composting hardwood bark.

HARRY HOITINK: Composting is important in crops such as bedding plants where time is critical. Composted bark is more uniform. Most fresh barks inhibit the growth of certain pathogens. In fact, hardwood bark helps control *Rhizoctonia*, although pine bark does not. Composting reduces this ability. However, hardwood barks usually contain toxins, which make it necessary to compost. The Southeast is fortunate, as pine bark is readily available, does not contain these toxins, and therefore does not require composting.

QUESTION BOX

LES CLAY: I would like to know more about icing plants for winter protection.

JAKE TINGA: Dr. Charles Hendershott, who is now at the University of Georgia, made his fame on studying freezing and thawing in plants. He prevented freezing in several crops of Florida oranges. When water freezes, it releases a tremendous number of calories. This is called heat of fusion. When liquid water is put on from an irrigation system and it freezes on impact, heat is released. I prefer to say cold is absorbed. As long as liquid water is put on, temperature will stay right at 32°F. If the water is turned off and ice forms, that ice will go to 31°, 30°, 29° and on down. When the temperature drops as far as 15 degrees below freezing, it is very difficult to put the water on fast enough to keep the temperature at 32°. I have iced out a field and saved that field just by turning on the irrigation. It must be turned on before freezing starts and left on until after all the ice is melted. Do not turn it off after everything is iced down.

BOB McCARTNEY: What about anti-dessicants?

JAKE TINGA: I have used anti-dessicants. Timing is very critical as they tend to flake off; thus, they must be applied repeatedly. My experience has indicated they are not reliable.

GARY HUTT: I tried microfoam last year for overwintering and had fairly good luck with it. I was wondering if anyone here has used microfoam and if so, how he used it?

JAKE TINGA: Microfoam is bubbly plastic foam material ¼ inch thick.

FRANK HOGAN: I have three rolls, but I haven't put it out