Table 1. Below are general guidelines for sample preservation for some common tests.

Tests	Preservation	Max. Storage Time
Acidity/alkalinity	Refrigeration	14 days
Boron	None	28 days
Chlorine residue	Analyze immediately	2 hours
Conductivity	Refrigeration	28 days
Metals	Filter, add nitric acid to below pH of 2.0	6 months
Nitrogen, ammonium nitrate, and total	Add sulfuric acid to below pH of 2.0, refrigeration	28 days
Pesticides, herbicides	Refrigeration	7 days
pH	Analyze immediately	2 hours*
Phosphorus	Add sulfuric acide to below pH of 2.0	3 days
Sulfate	Refrigeration	30 days

* pH may or may not change if storage time is longer. For irrigation purposes, the change during the shipment will not alter the medium or soil pH since it is weak-buffered.

A WOOD-BURNING FURNACE FOR HEATING PROPAGATION HOUSES

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The escalating cost of fossil fuels in the winter of 1981 led our nursery to seek a more economical and reliable method of heating our propagating and liner-growing houses. After much research and evaluation it was decided that a wood-burning furnace was the answer to our needs. It was important that we answer the following questions:

1. Could the wood-burning furnace provide the heat needed?

2. What unit was needed and what would it cost?

3. Was hardwood available?

4. How much time would be required to operate and maintain the unit?

5. How much could we save by using wood instead of fossil fuel?

During the winter of 1981 our nursery spent about $10,000 heating approximately 13,000 ft.^{2} of space. The space heated included three houses used for propagation and four houses used for growing-on the rooted cuttings. Three of our units were heated by means of hot water using black pipe, fin radiation as bottom heat in raised beds. These three units were heated with an oil-fired boiler capable of providing 1,000,000 BTU's per hour. The remaining four units were heated with gas-fired space heaters with fan-jet systems and convection tubes. In the three bottom heat units a temperature of 70°F was maintained while in the gas-heated houses a minimum temperature of 38°F was maintained.

During the winter of 1982 the combined cost of gas and oil was approximately $8,500 to maintain these temperatures. It was our opinion that had a higher temperature been maintained in the houses used for growing the liners, we would have had much better root growth and, therefore, would have had much faster and better top growth the following spring.

These two high-cost winters and the possibility of even higher fossil fuel costs in the future encouraged us to consider seriously using wood for heat.

After much research it was determined that we needed a wood-burning furnace capable of providing 1.6 million BTU's per hr. This size furnace would give us the capability of meeting our present requirements with the possibility of either increasing the heat a good deal over the former system or increasing by 10% the amount of space heated.

The initial cost of a unit capable of providing 1.6 million BTU's per hour was $20,000. This cost represented approximately two years' costs of heating by the present method. In addition the wood-burning furnace did not pose the problem of oil and gas fumes in the greenhouse.

It was determined that we would need approximately 50 to 60 cords of hardwood to fire our furnace during one full heating season, which in our case is October 15 to March 15. At an average price of $40 per cord, fuel cost would be $2,000 to $2,400 per season. Without adding any cost for operation and maintenance, the fuel costs described above represented an annual savings of approximately $6,000 or 70%. This fact alone sold us on the wood-burning furnace.

After the initial investment in the unit, the only other costs involved are the costs of a very small amount of maintenance and the cost of one man filling the furnace each morning and each evening. This chore takes about 10 min. each filling.

Judicious purchasing of the wood can also bring tremendous savings. Our experience has been that all wood dealers are different in the quantity and quality of wood delivered. We have tried many methods of buying wood, either by the semitruck load or in small pulpwood-truck loads. They all vary tremendously, and anyone is only as good as the man you are dealing with. The large semiloads come in 30 ft. lengths and require cutting into 5-ft. lengths, whereas the pulpwood comes in 5-ft. lengths and only requires restacking before use. The restacking facilitates the use of a front end loader or tractor to fill the furnace.

We are able to adapt our furnace in a manner that allows us to use our existing black pipe, fin radiation system in the one house. In the other houses we simply replaced the gas units with an exchanger that provides hot air to the fan-jet system. Each house is equipped with a thermostat, either soil or air, that activates a circulating pump that provides the needed heat for each unit being heated.

The furnace at our nursery is 28 × 8 × 8 ft. It is capable of using five-ft. log lengths, and the fire chamber is capable of holding 0.75 cords of wood per filling. The water volume is 6,000 gal. We try to maintain a water temperature of 180°F; it is possible for us to go from cold water to 180°F in three hours. During the normal winter night we fill the wood chamber at 5 p.m. and 7:30 a.m. During very cold weather (teens and lower twenties) we check the furnace at 11 p.m. and add wood if needed.

The unit used by our nursery is considered a medium-sized furnace. This manufacture makes units as small as 2,000 gal. of stored water with a 350,000 BTU output per hr. and a 0.25-cord wood chamber, utilizing 3-ft. long lengths. Their largest unit has a 25,000 gal. stored water capacity, 8 million BTU output per hour, three-cord wood chamber and a maximum log length of 9 ft. It is possible to use any combination of units in tandem to provide the needed BTU output.

All furnaces, like the make we use, have a high water-heat storage tank directly attached. None of the wood furnaces are pressurized. The units operate with an inducted draft, and the fire box is designed in such a manner as to provide high efficiency and low emission of excess gases. Our unit and all large wood-burning furnaces are tractor-fork loaded.

Maintenance of a wood furnace is very low. One must only remove the ashes on an average of once per wk. during the peak firing period. It takes one person approximately one hr. to remove the ashes and refire the furnace. The fact that the fire in the furnace must cool down some before the ashes can be removed is a disadvantage, especially in very cold weather when the water needs to be as hot as possible. It is also necessary to clean the tubes that run from the fire chamber to the stack. This allows the very hot air to pass through the water storage tank and thus heat the water on the average of twice per heating season. This task takes one person approximately 1½ hr. and must also be done when the fire is completely out in the fire chamber. This could also be considered a disadvantage as it may have to be done once during very cold weather at the peak of the heating season.

In summary, our wood-burning furnace has proven to be very economical, clean and safe. It is our belief that a wood-burning furnace can save one a minimum of 50% and a maximum of 80%. One statistic that bears this out is the fact that wood cost per 100,000 BTUs is $0.15 as compared to a fossil fuel cost of $0.73 per 100,000 BTUs[1].

The following trade publications give additional information on wood-burning furnaces:

Greenhouse Grower, April 1984: Energy:Dollars & Sense
Grower Talks, April, 1985: Fuel:Some New Answers
Florist Review, March, 1985

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[1] Florida Furnace Corp., Box 637, Apopka, Florida 32703.

AN INNOVATIVE APPROACH TO THE USE OF BOTTOM HEAT

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The idea of bottom heat in rooting cuttings is not new. The major drawbacks for most systems are the cost of installation, the purchase of equipment, and the maintenance. The system developed at Tawakoni Plant Farm has proven to be cost-effective and has returned the original investment more than twice in its first year of use. It was very easy to install and was built out of materials readily available through local supply firms. The goal was to install a system not so much for protecting liners, but more for rooting cuttings during the winter months. Both objectives have been achieved with this system. Admittedly, the winter of 1983-1984 was a deciding factor in building the system. That year almost ⅓ of all rooted liners were lost to freezing, causing serious planning, financing, and organizing problems. This system has the potential to alleviate losses of that nature and expand the propagation season to a year-round endeavor.

MATERIALS AND METHODS

The propagation department of Tawakoni Plant Farm consists of eight 30 × 96 ft. quonset-type greenhouses with 30% shade coverings. All greenhouses were covered with inflated