ABC's of In-ground Heating & Alternate Fuels

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Root zone temperature is more critical than leaf temperature in achieving good plant growth. If the optimum root zone temperature is maintained, then air temperature in the greenhouse can be 5 - 10ºF cooler, saving energy.

For winter operation, installing 1" thick polystyrene or polyurethane insulation board to a depth of 18" – 24" below grade will save considerable heat and keep the soil near the sidewalls at a warmer temperature. Insulating above grade to bench height or so that the plants are not shaded will also give significant savings.

System components

The basic floor system consists of pipes embedded in the concrete, sand or soil. Warm water pumped through the pipes conducts the heat to the plants placed on the floor or in the soil. The floor material distributes the heat evenly across the floor surface. In New England, a floor heat system will provide about 25% of the greenhouse heat needs on the coldest night. Typically, 15 to 30 Btu/sq ft of floor area can be obtained from the root zone heating system. The remainder has to be made up with above ground perimeter radiation or air heaters.

Heat source

For heating small areas, less than 3000 sq ft, a low-cost, domestic hot water heater is usually the best choice. These are available in natural gas, propane and electric models in sizes to about 45,000 Btu/hr. Select a heater with a glass lined tank. The installation is simple in that besides the water heater all that is needed is an expansion tank, air eliminator, PRT safety valve, circulating pump and remote bulb thermostat. The thermostat on the water heater is usually set at 100 to 110ºF. The soil thermostat that controls the pump is set at the desired soil temperature.

Hot water from an existing or new boiler can also be used. One or more circulators and tempering valves are needed to feed the root zone heat. Because the return water from the root zone is cool, a non-condensing boiler should not be used. Cool water, less than 135ºF can cause condensation that is highly acidic and can damage the boiler. A tempering valve that protects the boiler could be installed to warm the return water. A better option is to have a condensing boiler that uses the heat from the flue gases to warm the return water.

Another installation that works well is to install a heat exchanger between the boiler and the root zone heat. A heat exchanger isolates the boiler water from the root zone tubing water. A circulating pump moves the hot boiler water on one side or the heat exchanger and a second pump passes the water through the other side. Heat exchangers are used if the root zone tubing is filled with glycol solution in a greenhouse that is shut down during the winter. It is also a common installation in a system that doesn't have an oxygen diffusion barrier such as polyethylene pipe.

To reduce heating costs, an outdoor wood boiler or corn fired boiler could be used. These are available in many sizes. As there are state and local restrictions on their installation, check with the local building department before purchasing one of these units.

Heat distribution in the root zone
It is best to use a material such as PEX, a cross-linked polyethylene tubing that has an oxygen diffusion barrier. PEX tubing is available in sizes from 3/8" to 2" and in roll lengths to 1000'. Typical size for floor systems is ½" for loops up to 200' and ¾" for loops to 400'. Tube spacing is usually 9" to 12" on center.

Some growers have used low-cost Schedule 80 polyethylene pipe in soil or sand installations. With a glass lined hot water heater and no ferrous components, the life has been good. For soil grown crops, placing the pipe 8 – 12" deep will allow roto-tilling of the soil. Installation can be done by plowing a furrow and then laying the pipe in the bottom or by purchasing a pip-laying chisel that attaches to the drawbar of a tractor. For surface installation, the pipe is laid on top of the ground underneath gro-bags or containers. The piping is installed as loops fed by a supply header with the other end connected to a return header. Using a reverse return system, the flow through each loop travels the same distance giving uniform heating.

Pumps
Circulating pumps are used as a good flow is created without much energy. Inline or wet rotor circulators are most common. Place a shut-off valve and a union on both sides of the pump so that it can be serviced or replaced easily. When sizing the pump, the flow should be about 2.5 feet/min for ½" or ¾" pipe. This keeps the temperature difference between the supply and return ends of the loop to between 5 and 10ºF. The head or pressure loss is determined by the number and length of loops in the system and the pipe size. The pump is best located near the expansion tank to reduce pressure differences.

Controls
A remote bulb thermostat is the common control. Placed in the soil or container it activates the circulating pump when heat is needed. When water is supplied by a boiler, controls that modulate water temperature or a variable speed pump may be used.