Grower 101:

Exploring Underbench Heating Options

Root zone heat can benefit crops and help lower energy costs, but it is important to first select the right system components for your operation's needs.

By John Bartok, Jr.

Uniform temperature in the root zone is difficult to achieve with a furnace heating system that circulates heat over the top of the crop or a boiler that pumps water through fin radiation along the sidewalls. Locating the heat on top or under the benches warms the containers first before it rises to heat the air, and for most crops, soil temperature is more critical to good growth than air temperature.

An added benefit to root zone heating is the potential savings in fuel costs throughout the heating season. Air temperature in the greenhouse can be 5-10° F lower than soil temperature and still achieve excellent growth. This lower air temperature means the heat loss between inside and outside the greenhouse is less, which results in a 10 percent or more reduction in fuel usage.

Research by Bill Roberts and others at Rutgers University has shown that about 20 Btus per sq.ft. of bench area is adequate to provide root zone heat without drying plants too much or killing tender roots. In Northern climates, this will provide about 25 percent of the total heat a greenhouse needs on the coldest night. During spring and fall, it will probably provide all the necessary heat.

The components of a root zone heating system include a hot water heat source, distribution piping, radiation and a control system. This article will examine these components to see what the options are.

Select A Hot Water Source

If you presently have a boiler system heating the greenhouse, it can probably be modified to give the 100-130° F water needed for root zone heat. The existing capacity should be adequate as the heat is just being redirected from fins or pipes to the root zone area.

If you have a condensing boiler, one in which the boiler can operate safely with a return water temperature less than 140° F, then the high-limit switch is set to the highest temperature water that you want in the root zone piping. If the boiler will be used for both high temperature (180° F) and root zone heat, then a bypass loop and mixing valve will be necessary to get low-temperature water.

Most greenhouse boilers are the non-condensing type and require a bypass loop and mixing valve to keep the water temperature in the boiler above 140° F. A 3-way valve is commonly used to allow water from the boiler to be mixed with return water from the root zone and directed back to the boiler or mixed with the return water and fed into the root zone system.

With the current interest in alternative energy systems, wood and coal boilers are making a comeback. Because fire control is more difficult with these systems and heat continues after the damper is closed, a buffer tank is usually installed. This tank, with a capacity of several hundred gallons, stores the excess hot water from the boiler. After mixing it with the return water from the root zone, the water is then distributed back to the root zone at the desired temperature.

For providing root zone heat to a single hoop house or small bench area, a domestic hot water heater will do an excellent job. These heaters fired ➧

Top: *A small boiler is a good source of hot water for the root zone heating system. Different temperature zones are supplied water from circulating pumps and controlled by remote bulb thermostats.* ***Bottom:*** *For small bench areas up to 2,000 sq.ft., a domestic hot water heater works well. The thermostat on this oil-fired heater is set to the desired 100-120° F water temperature. (Photos: John Bartok, Jr.)*

Pots are warmed from the bottom on this small-diameter EPDM rubber tubing system.

by gas, oil or electricity are available in capacities from 30,000 to 40,000 Btus per hr. and will heat up to 2,000 sq.ft. of bench area. Larger commercial water heaters and instantaneous water heaters have also been used with good success.

Select Appropriate Piping

The distribution pipe that carries hot water from the boiler to the root zone system needs to be selected carefully. For the bypass loop and piping near the boiler, metal pipe — either copper or iron — should be used, as the water temperature is hot. If the water temperature that will be distributed in the root zone is less than 130º F, PVC is a good choice because it softens and sags at temperatures above 140º F.

The system should be designed so the pipe loops are as short as possible to reduce friction and heat loss. Locating the boiler near the center of the bench area to be heated will accomplished this. Using a 3-pipe, reverse return system will provide the same temperature water to all the loops. The system can be zoned so individual benches or areas in the greenhouse can be heated to different temperatures. Each zone requires a separate circulating pump and piping. Insulate the high-temperature and large-diameter pipes that carry large volumes of water to save energy.

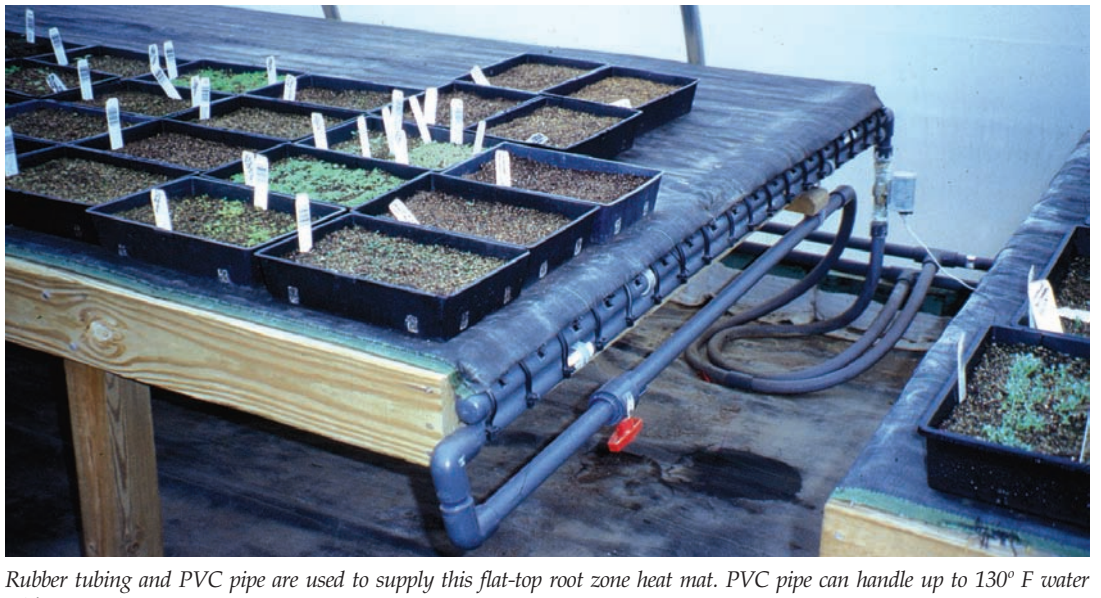
Select Your System

There are several systems that are used to provide heat in the bench area. Containers in contact with the heat source will get conductive and convective heat. Where there is no contact, the heat is transmitted mostly by radiation.

Bench mats or EPDM tubing spaced 2-3 inches apart works well for propagation and containers. The water flows through the pipes from the warm-water manifold or pipe and loops back to the cold-water manifold or pipe. The tubing and mats should withstand UV light, fertilizers and high temperatures.

Some growers have attached PEX (cross-linked polyethylene) tubing to the underside of wire mesh benches. Besides being resistant to abrasion and chemicals, PEX stops oxygen diffusion, which can cause corrosion in boilers, tanks and plumbing.

It is also possible to suspend bare iron pipe or low-output fin pipe about 18 inches beneath the bench. Usually the pipe is hung by a chain or hooks to the bench support frames. Filled with 120º F water temperature, ➧



Rubber tubing and PVC pipe are used to supply this flat-top root zone heat mat. PVC pipe can handle up to 130º F water without sagging.

Left: *Low-output fin radiation is easy to install and out of the way of plant handling. Rubber tubing connects the separate runs of aluminum pipe.* ***Right:*** *A plastic weed mat material attached to the bench sides contains the heat underneath the bench and allows the air temperature to remain cooler.*

an 1½-inch bare steel pipe will give off about 50 Btus per linear foot. A three-fourth-inch-diameter aluminum pipe with two 1-inch fins will give off the same number of Btus and hold only one-third the volume of water. This reduces the water needed in the system and the overshoot in temperature once the system shuts off. Under a 6-ft.-wide bench, a loop of either the bare pipe or fin will provide the needed 20 Btus per sq.ft.

Circulating Pump And Control

A heating system circulating pump is typically used to move heated water through the radiation. In a system with multiple zones, either one pump per zone or a single larger pump with zone valves is used. The pump needs to be sized depending on the number of loops and the friction loss in the piping. Being a closed system, there is no head loss due to pipe elevation.

The sensor that controls the flow of hot water to the root zone radiation should be placed in a representative pot or flat in the middle of one of the benches. The simplest control is a thermostat with a remote sensor bulb. The root zone system can also be connected as the primary heat zone to many controllers and computers.

Operating Hints

If you install the radiation under the bench, attaching an 18-inch skirt to the sides of the bench will trap the heat and keep it from escaping and heating the air in the greenhouse. Weed barrier mats or plastic sheets work well for this.

To prevent a chimney effect from losing the under-bench heat, keep the bench full of plants, lay a weed barrier mat on the bench top before placing the pots down or cover any sections where plants have been removed with plastic sheeting or other material.

Root zone heat on benches can provide more uniform temperature control than a heating system used to maintain air temperature in a greenhouse. This results in better germination of seed, faster rooting of cuttings and better plant growth and disease control in potted plants. The system will pay back quickly in fuel savings due to the lower air temperature that can be maintained. GPN

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