ROOT ZONE HEATING DESIGN CONSIDERATIONS

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Root zone heating or soil heating is an old concept being modified with new equipment to produce high quality, uniform plants in a relatively short period of time using little energy. In basic terms, the techniques used simply circulate hot water through plastic tubing to provide even heating throughout the soil medium. Two major types of root zone heating systems are commonly used. The first utilizes ¾-in. plastic tubing and the second uses the similar EPDM (ethylene propylene diene monomer) tubing. Both systems work well when engineered and installed properly (1).

The root zone heating system has a boiler, supply lines, a header system, runs or loops of tubing, a return line to the boiler, a pump, and a quality thermostat. The root zone heating system should not be the only heat supply for the greenhouse. Secondary heaters must be installed to assure warm air temperatures during extreme cold periods and to help melt problem ice and snow. Root damage from high soil temperatures may occur if the system is used to heat the whole greenhouse. Many growers found that with root zone heating (soil temperatures 70 to 80°F) air temperatures were also reduced (50 to 60°F) as the heat does not easily escape from the soil.

Some growers have run the root zone systems off present boilers, but most are installing cost-saving, highly-efficient boilers. These boilers use less water and take up smaller amounts of growing space in the greenhouse. When determining the size of boiler to use, a figure of 40 BTU/hr/sq ft of greenhouse is recommended in northeast Ohio. For example, if a greenhouse measures 100 × 18 ft, a 72,000 BTU boiler would be appropriate for the system. Remember that there must be backup heaters in case one system fails. Most of these boilers are handling water heated to around 140°F with water returning to the boiler approximately 30°F cooler. These systems usually operate between 5 and 15 lb pressure. The best quality tubing should be used at all times to prevent leaks.

If a supply line feeds more than one head system, it will be necessary to install flow control valves. If a grower has uneven heating across a root zone, consider installing throttle valves. These valves can be controlled manually to increase or decrease water flow and control temperature in the same way. Growers may wish to install one-way control valves if the systems are installed on the floor so heat does not flow to the heat zone when the pump is off. Growers have added antifreeze to a level of −5°F when starting their systems yearly. This will help to keep the system clean longer. It is important to flush the system at least once a year to keep it flowing evenly.

Most growers installing this system are moving to rigid schedule 40 or even 80 PVC tubing in the supply lines and headers. This is done to prevent warping which could lead to cracks or leaks in the system. Some cracking occurs at joints when poorer grades of PVC are used in the system. If the system is being used on movable benches an extra length of flexible hose will prevent cracks in the headers.

Uneven heating can be a problem in root zone heating. If the hot water feeding header and the cold water return header are the same length, adding an extra length to the return header (Fig. 1) will even out the resistance and thereby even out soil temperatures. With ¾ in. tubing, where loops may occur at the end of the bench, a mixer header can be installed to prevent kinking and restricted water flow. This is simply a piece of PVC the same size as the header which will mix the water and return it to the cold water header on a more even basis (Fig. 2).

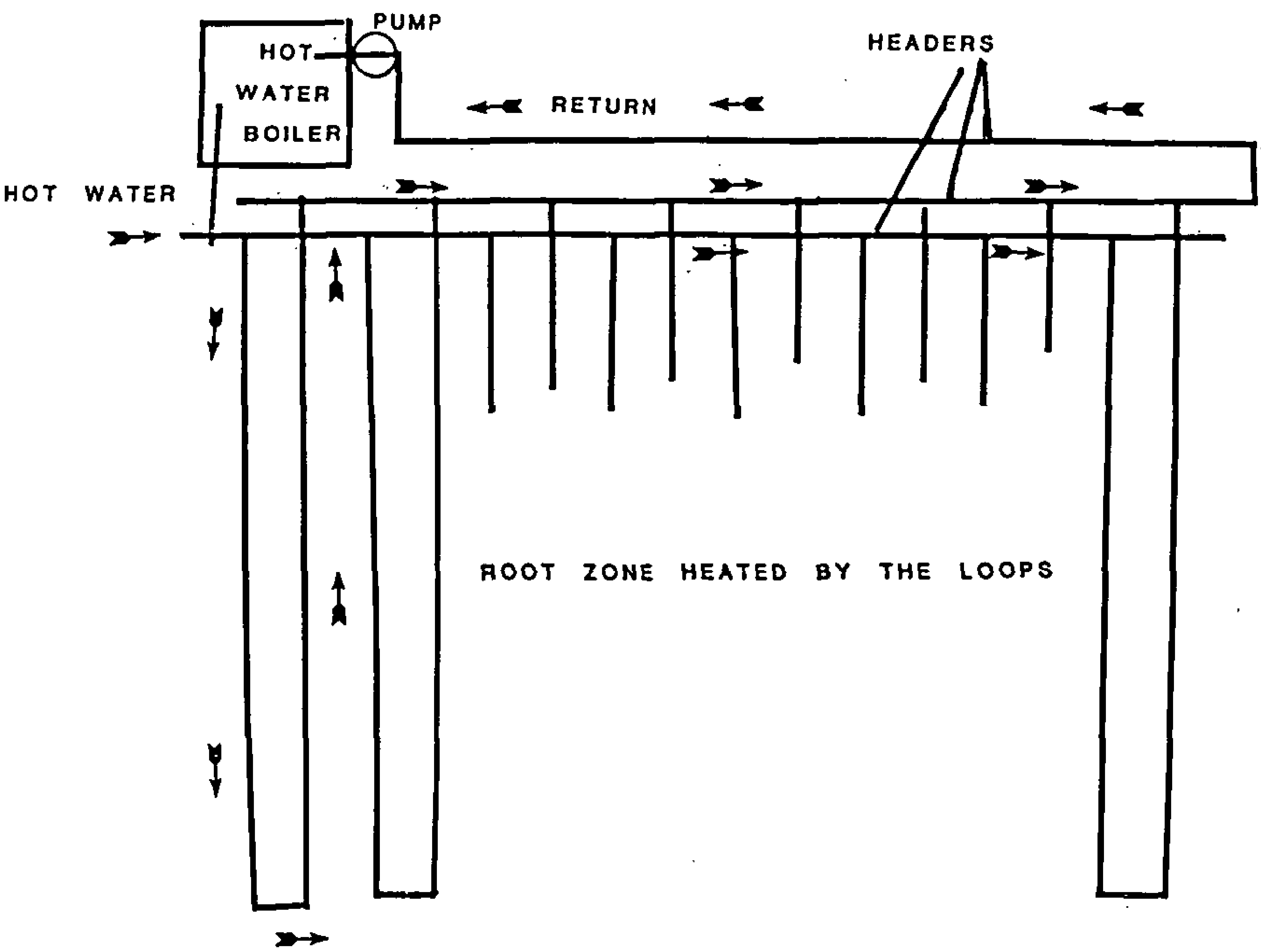

Figure 1. Layout of piping for root zone heating.

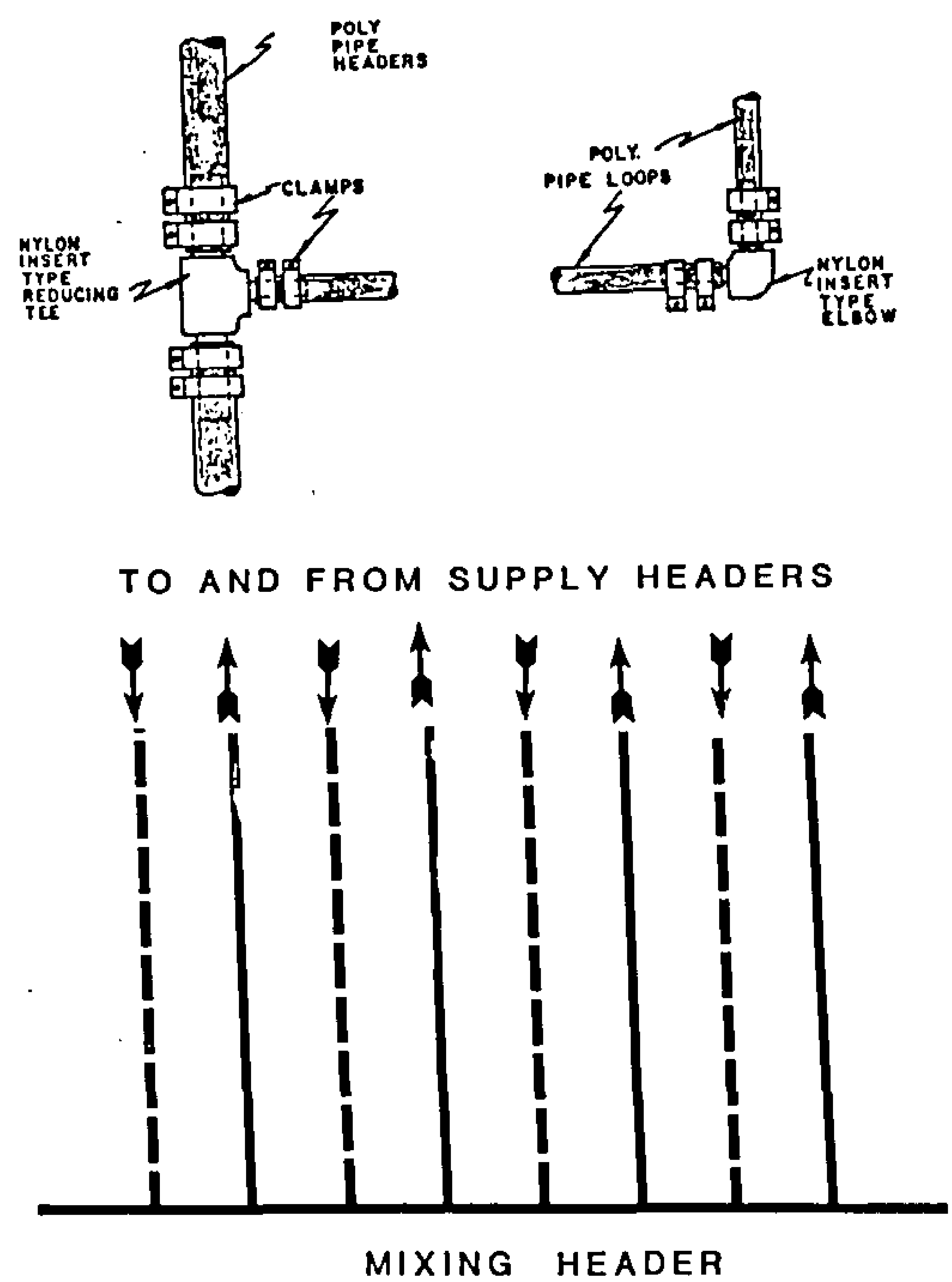

Figure 2. Layout of piping for mixing header. Solid line = cold water. Dashed line = warm water.

When installing these systems, it is best to do it in warm weather; the tubes expand in warm weather and contract in cooler weather. If tubes are installed in cool weather it is possible the lines will snake out of shape when heated. This will be less of a problem with ¾ in. tubing than with the smaller EPDM type tubing.

Most ¾ in. plastic tube systems the researchers worked with have been placed in in-ground beds. The tubes are larger so they carry more water which means fewer tubes. This system will perform just as well as the EPDM system if the tubes are buried at the same depth as they are spaced in the loop. For example, if the tubes are spaced 12 in. apart in a loop, they should be buried 12 in. deep. This allows the heat to move outward and upward and creates a more even heating pattern. The total length of each loop should be kept in the 200 ft range—sometimes longer, sometimes shorter, depending on the length of the greenhouse. Finally, the sand in which the tubes are buried has to be kept moist. This means heavier watering and, in one case, a subsurface watering system was installed. If locations were to dry out, it would create hot spots. Remember that with the ¾ in. tubing a larger header may be needed. A good rule to follow is—if you have a bed with 4 loops, a 1½ in. header should be used.

The small EPDM tube systems are the most commonly found system in northeast Ohio. These flexible tubes are designed to sit on benches as well as on the floor, or be buried a couple of inches below the floor surface. EPDM tubes carry smaller amounts of water and therefore need to be placed closer together. One grower initially placed the tubes on a bench made of styrofoam. This created uneven heating in bedding plant trays as well as in shallow flats. When 4 in. pots were placed on these benches so the pots sat on both the warm and cool water tubes, the pots showed fairly even heating in the root zone. Eventually the grower covered the tubes with 2 in. of sand and piece of black plastic to even out the heating. Growers using expanded metal benches, growing plants in rooting flats, or quart pots had no problems with uneven heating. In these cases the heat has a chance to mix in the air below the bench and create a more even heating of surfaces above.

Growers using the EPDM system on ground floors with deep rooting flats have very even root zone temperatures. The fact that these flats are watered or misted daily and the depth of the soil is equal to the spread of the tubes probably aided the even distribution of heat.

Some growers have buried the EPDM tube in a couple inches of sand or gravel. This will allow for more uniform temperatures if the grower decides to grow in small containers or shallow flats. One grower has also placed a black woven poly tarp over the beds to keep them clean and weed-free.

Growers have run into several problems. Root zone heating systems create increased humidity in greenhouses and require venting to control condensation from the roof. Research has also shown that many growers must water much heavier than before because the growing containers are drying from the bottom up. Heat loss from side walls can be a problem and growers are advised to insulate greenhouse sidewalls down to 2 ft below the surface with 2 in. of polystyrene. It is important to use extruded and not expanded polystyrene. Some growers are installing an extra loop along sidewalls if even heating is not achieved using other methods such as insulation.

In conclusion, research has shown that root zone heating systems when installed properly can help growers increase plant growth. Root zone heating systems require an independent back-up heating system. Only the best quality materials should be used and the system should be properly sized for the structure. Annual maintenance and flushing of the system is necessary to assure the best performance. More research will also be needed in the future to further system energy savings and develop more efficient system designs.

LITERATURE CITED

1. Brugger, Michael F. January 1983. Design Guidelines for Soil Heating in Greenhouses. OSU Cooperative Extension Service, The Ohio State University, Columbus, OH.

HAROLD STONER: Have you considered using a heat pump?

RANDALL ZONDAG: One grower is using a water to air system to heat an entire greenhouse. One of the problems is that the heat pumps cannot heat the air to a high enough temperature where we want them to be. We are using the ground water as a supplemental source and pass it through a hot water heater.

HORIZONTAL AIR FLOW IN WINTER STORAGE HOUSES

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Air movement or circulation is certainly not new to the greenhouse or nursery industry. There are many ways in which we have succeeded in doing this over the years: by opening vents, use of fans to pull air through, fan jet convectors with the punched poly tube and duct fans to create a horizontal air flow.

Horizontal air flow, or HAF, is the topic of my subject today. What exactly is HAF? It is simply air circulating horizontally in a column around the house. Fans located on opposite sides of the house provide a gentle but continuous circulation which mixes the air from top to bottom in the structure. We have used HAF in our growing houses since the advent of double poly during the energy crisis. Double poly sealed our houses so tight we found there was no natural air movement. Many articles have been written over the years about HAF in growing houses, so we will move on to cold storage houses.

Why would we want to install HAF in these structures? Are there advantages or maybe disadvantages to this method? The cold storage houses with minimum heat I am going to talk about are all 14 ft wide and range in length from 184 to 248 ft with an average height of 7 ft 6 in. at the peak.

Would HAF improve the quality of life for the plants? Because we had experienced some fungus problems in the past in these houses, it was thought that by gently moving the air around the plants 24 hr a day we could either eliminate or greatly reduce this problem, thereby not having to use as much fungicide. We did create