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63. Consider design with a new floor heating system. Both, A. J. and Reises, E. Greenhouse Management and Production 27(12):35-37. 2007.

Tube diameter and location impact the effectiveness of a greenhouse floor heating system.

By A.J. Both and Eugene Reiss

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Consider design with a new floor heating system

WHEN GREENHOUSE ENGINEERS design heating systems, they often determine the outside design temperature (e.g., the minimum temperature that is not exceeded more than 1 percent of the time). The design temperature is the outside temperature a greenhouse encounters while its heating system tries to maintain a target indoor temperature.

In the Northeast, greenhouse heating systems are designed with a maximum heating capacity of 70-130 Btu per hour per square foot of floor area. Typical systems deliver 20-30 Btu per hour per square foot of floor area.

Higher delivery rates are theoretically possible, but would likely result in crop damage since plants are placed directly on the floor.

Floor-heating installations

Greenhouse floor-heating installations include %-inch tubing installed on 12-inch centers or -inch tubing on 9-inch centers. With concrete floors, the tubing is often attached at regular intervals to the reinforcing wire before the concrete is poured. Tubing can be made of cross-linked polyethylene (PEX), polypropylene and PVC. Specifications include a temperature rating of 140°F, pressure rating of 100 pounds per square inch and an oxygen diffusion barrier (to prevent corrosion).

The minimum desired water velocity through the heating tubes is 2 feet per second so that air bubbles and sediment are removed. As a result, to keep internal friction losses to a minimum, the maximum heating tube loop length is 400 feet for X-inch tubing and 200 feet for %-inch tubing.

Typical greenhouse floor heating includes 3/4-inch tubing installed on 12-inch centers.

Floor heating findings

The research included data collection at Rutgers University's open-roof greenhouse outfitted with a heated ebb-and-flood irrigation system, as well as construction and validation of a computer simulation model capable of evaluating different scenarios that included a 2-inch layer of simulated growing media (to simulate plug flats) placed on the floor.

Here are some results from the trials.

1. Raising the heating tube

Floor heat is uniformly delivered directly to the root zone of a crop on the floor.

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position in the simulated 4-inch solid concrete floor slab resulted in higher surface temperatures and surface heat fluxes, while the soil flux decreased only slightly. In addition, the temperature uniformity at the floor's top surface decreased. When temperature uniformity is important, a lower tube position in the floor slab should be used (install tubes in the lower one-third of the floor slab).

2. The 1/2-inch-diameter heating tubes placed on 9-inch centers increased both surface temperature and surface heat flux compared to the 3/4-inch-diameter tubes placed on 12-inch centers, regardless of tube position.

Although there was also a greater heat flux to the soil below, the percentage of the total heat input to the floor that is transferred to the soil underneath the floor slab did not increase. Research simulations

Floor heating pros and cons

PROS

1. The heat is uniformly delivered directly to the root zone of a crop placed on the floor, resulting in better crop growth and development.
2. The resulting higher root zone temperature often allows for a reduction in the greenhouse air temperature, resulting in potential energy savings (although the impact on crop production should be carefully considered).
3. Heating tubes are embedded in the floor, so the entire floor can be used to produce crops.
4. The floor slab acts as a heat buffer that will continue to provide heat during heating system failures or power outages.

CONS

1. Floor heating is generally more expensive to install compared to other heating systems.
2. The response time of a floor heating system is slow (in the order of hours).
3. Without proper insulation, some heat will be lost along the perimeter and to the subsoil underneath the floor.
4. Crops grown directly on the floor require workers to bend over.

showed that for a 4-inch solid concrete floor slab the amount of heat lost to the (dry) subsoil was approximately 10 percent of the floor's top surface heat flux.

3. The 1/2-inch-diameter tubes placed on 9-inch centers provided higher average growing media temperatures and higher floor surface heat fluxes for the simulated supply water temperatures when compared to the 3/4-inch-diameter tubes placed on 12-inch centers.

At the same time, for the simulated supply water temperatures, the smaller-diameter heating tubes placed closer together provided considerably more uniform temperature distribution.

4. There appears to be no significant economic disadvantage to installing 1/2-inch-diameter heating tubes on 9-inch centers compared to 3/4-inch tubes placed on 12-inch centers. Also, the research simulations showed a considerable increase in media temperature uniformity when the smaller-diameter tube is modeled compared to the larger-diameter tube. Placing smaller-diameter tubes closer together is the best choice of tube diameter and spacing for plant production when growing plant flats on a heated floor.

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