SOIL HEATING FOR TRANSPLANT PRODUCTION

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The well-documented benefits of soil heating have developed a considerable interest in greenhouse floor heating. Traditional green house production systems have used benches to elevate plants from the cold soil. In most systems heating pipes are installed under the benches or surface bench heating systems are used to increase soil temperatures.

Bedding plant operators have traditionally grown in polyethylene glazed plastic film greenhouses and have placed the plant material directly on the floor to eliminate the cost of benches. This growing system can create a serious problem with cold soil temperatures. Neither warm air nor hot water heating systems are able to maintain warm soil temperatures without operating the greenhouse at ambient temperatures much higher than necessary, dramatically increasing cost of energy for heating. Soil heating systems reduce operating costs when growing on the floor. The temperature of the microclimate at the floor canopy can be maintained at the proper level with lower ambient air thermostat settings. This feature significantly reduces heating costs with savings depending upon the crops being grown.

Types of soil heating systems in the floor

Growers have successfully used soil heating systems with various types of floor construction. These include, gravel, sand, soil, porous and solid concrete. Each of these systems works well from the heating standpoint and have varying favorable characteristics from the production standpoint. Soil, gravel and sand floors are the least expensive but offer the least benefits from a materials handling standpoint and ease of worker performance. The concrete options are the most expensive to install but provide excellent materials handling characteristics, easier maintenance, long life, and weed control.

A word about temperature

Table 1 illustrates temperatures at various locations in a 1/2-acre greenhouse. The greenhouse is 210 feet wide with two 100' floor-heated sections on either side of a center aisle which is 10 feet wide. The important temperature differences are noted in Table 1 between the temperature under the pot in the alley (the paved walk area), where there is no floor heat, as compared to the temperature under the pot in the floor-heated area. These plants are within a few feet of each other, yet the soil temperature in the pot on the unheated floor is 14 degrees F cooler. Crop performance suffers significantly with low soil temperatures. Greenhouse operators growing on unheated floors can expect the soil and floor canopy temperature to be at least 10 degrees F lower than at the temperature recorded at the 6 foot level. This is not a problem in itself because the temperature at the 6 foot level can be elevated 10 degrees F and maintained to give the desired floor temperature. However, the greenhouse would have to be operated at 75 degrees F to give the desired soil temp. of 65 degrees F leading to very high energy costs.

Many growers have saved energy by operating the greenhouse at least 5 degrees F lower at the 6' level than conventional settings. For instance, some growers with floor heating can operate the greenhouse at 55 degrees F rather than 60 degrees F with the same crop response because the crop on the floor is, in fact, at the desired higher temperature.

Supplemental heating required

Each warm floor heating system should be viewed as a supplement to a greenhouse heating system. Since the floor operates at relatively low temperature, it cannot deliver all the heat required by the greenhouse during very cold periods. The actual percentage of the total which is supplied depends upon location and heating demand and time of season. Approximately 30-50% of the design heat load can be delivered from the floor system. Overhead unit heaters either combustion type or hot water to air heat exchanger units are popular to meet the heating design loads required for a greenhouse. The uniformity of the warm floor overcomes many of the heat distribution and uniformity problems associated with unit hot air heaters. Overhead pipe loops can also be used. Although more costly, these provide excellent temperature uniformity throughout the greenhouse.

Table 1.	Floor heated area			Alley	Foyer	Shop
	6 P.M.	9 P.M.	8 A.M.	8 A.M.	8 A.M.	8 A.M.
Outside	30	20	3	—	—	—
Soil temp. in pot	62	61	64	—	—	—
Under pot	60	63	67	53	55	39
12" level	60	61	65	58	55	45
72" level	65	65	67	70	68	63

Selection of Pipe

Present information indicates that virgin polyethylene pipe, cross-linked polyethylene PEX, polybutylene pipe, larger diameter EPDM flexible tubing, CPVC or polyvinylchloride pipe offer the best design for economy, corrosion resistance, and labor of installation. However, just recently Shell Chemical Co. withdrew polybutylene pipe resins from the United States market as a result of a recent legal settlement over floor systems which failed in homes and commercial buildings. With the coming unavailability of the polybutylene pipe, which has been the industry standard for many years, it appears that cross-linked polyethylene pipe, PEX will be the logical replacement for headhouse applications as well as greenhouse applications where concrete ebb and flood irrigation systems will be used.

Proper water temperature is critical to the effective operation of floor heating systems. Normal operating temperatures are from 90 degrees F to 110 degrees F to maintain a low temperature drop in the loop, around 5 degrees F, so that a uniform soil temperature can be achieved in the crop. When a higher heat release from the greenhouse floor is needed, such as in germination areas, it is advisable to space the pipe closer (6-9") than to increase the temperature of the water in the system. This avoids the problem of uneven heat distribution. Observing strip growth in seedlings is a good indication that the temperature of the water in the pipe is too high. Temperatures higher than recommended also increase the probability of deformation of the fittings with the potential for failure.

When the floor choice is either porous concrete or concrete, connections for the coiled pipe loops can be easily made at the ends of the greenhouse and the connections covered with gravel so that leaks can immediately be detected and repaired without having to remove either porous or solid concrete.

System design

Current design practice for the floor system is to estimate that approximately 20 btu/hr are given off to the greenhouse from each square foot of floor with a 90 degrees F average water temperature in the plastic pipe loop and a 60 degrees F ambient temperature for potted plant or flat production on the floor. Tightly spaced flats may limit the rate of heat transfer but usually normal irrigation practices ensure that the heat transfer is adequate. Lower ambient air temperatures and higher soil temperatures will increase rate of heat transfer from the floor. If higher water temperatures are selected then closer pipe spacing may be required. A good conservative design practice is to provide 30 btu/hr per square foot from the hot water heating system. However, when calculating the total heating requirement from the greenhouse, consider that only 20 btu/hr per square foot is available from the floor and provides the remainder of the heating capacity needed for the greenhouse from an overhead heating system.

Water flow rates in the pipe loops are very important. A velocity of 1.5 to 2 feet per second gives adequate heat transfer and helps eliminate pockets of air which are prone to accumulate in a horizontal pipe system. This translates to a flow of 2 to 2.75 gpm per loop with 3/4 inch pipe. Pipe loops should be no longer than 400 feet to minimize friction and provide a balanced design for the system pump. Shorter pipe loops are adequate but require a larger pump for the system since each loop requires the aforementioned flow.

Those interested in learning more about floor heating or desiring to install a system might benefit by purchasing the publication E207, **Soil Heating Systems for Greenhouse Production**. It is available for $4.00 by writing William J. Roberts, Bioresource Engineering Department, Rutgers University, 20 Ag Extension Way, New Brunswick, NJ 08901-8500. Make check payable to Rutgers University.

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