We can conclude most definitely that bottom heat provided faster rooting and a higher percent of take. Considering the relatively short period required and the low cost per plant produced, bottom heat is an economical approach. The rooted cuttings produced under bottom heat conditions showed better health and growth with very little die-back, leading to a better quality plant.

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BIOTHERM BOTTOM HEATING IN PROPAGATION

TED SPRINGER

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Bottom heating is not a new idea. Fifty years ago steam-heated greenhouses were heated from the ground up. Today we are returning to that method as it becomes more and more critical to use energy in the most efficient way possible. Now, however, we are interested in the number of cubic feet actually heated as well as in minimizing the level of heat used. We are interested in the transfer of low-grade heat. The Biotherm system does this by using hot water as the heat carrier. We do not need or want high temperatures in our growing benches. One mum grower quite accidentally discovered the advantages of bottom heat when he left his Modine unit on the floor following a tornado. He began to notice increased plant growth, which dramatically illustrated what we have known all along: soil temperature is what counts! For many plants a 70°F thermostat setting will give a good crop. But this is head high! It is not the same with bottom heat. Check the soil temperature where the best plant is growing to determine what a 70°F degree thermostat setting really means. Different containers and media affect the gradient between air and root-zone temperatures but, in general, the difference is around 10°F.

What we want, then, is to reduce energy requirements by minimizing the heat level and space heated. What is extremely important is that in doing so we provide maximum temperature uniformity. Only then can the bottom-heat technique become an efficient part of an overall, automated production system, which is the only way to achieve economic efficiency. Remember, any time one component of a system is changed, all others must be adjusted as well. The plants will not automatically adapt; management practices must be re-evaluated and changed if necessary.

One of the most important reasons for insisting on even heat distribution is that watering requirements throughout a crop are then the same, provided containers and medium are the same. Effective automatic watering is impossible unless this is true. The Biotherm is laid on 2-in. centers. With this spacing it is possible to maintain even heating through a single tray or between separate containers on the bench without burning it. We do not suggest putting a capillary mat over the tubes when plug trays are used. With such close spacing it is important that no bench space is sacrificed for the tubing itself. Yet to maximize energy utilization we wanted to avoid burying the tubes. Although the tubing does not collapse even when heavy containers are set on it, it is usually more convenient to lay welded wire on top of the tubes. When the tubes are buried, heat transfer is limited not by the temperature of the water but by the heat transfer coefficient of the material in which it is buried. Even the new porous cement cuts down efficiency tremendously. To give some idea of what this means, the maximum amount of heat energy that porous concrete can put out is 25 BTU/ft^2, or about half of what is needed in a double-layered poly house when outside temperature is 0°F. With uncovered tubing, it is also possible to provide microclimate as well as soil temperature control by allowing more actual heat transfer from the system into the growing environment.

We looked at many different materials before deciding on one. It is an ethylene propalene diamine material that is similar to neoprene with a temperature range of 50° to 300°F. It is resistant to almost anything but petroleum oil compounds. It is flexible, and it is important to allow for expansion when it is filled with warm water. A flexible connecting hose can take care of this slack. All headers and connections can be put under or outside the end of the bench to avoid loss of growing space. At first, fastening all of this footage of tubing to the benches seemed impossibly time consuming. We have now developed a type of nylon material, which we call a tube-gribber, that can actually hold the tubes in place without screwing down clamps.

By using this type of bottom heating it is possible to take advantage of newer production systems much more effectively. In addition to improving automatic watering results, the flexible hose and connection makes it possible to use rolling or removable benches quite easily. Remember that with any production routine it is important to evaluate each part and determine how well a new segment will fit into the whole. This must be done on an individual basis. Test a system such as Biotherm first on a small basis. By so doing, much can be learned to make complete installation and management much easier and much more profitable.

CHLORINATION OF IRRIGATION WATER

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Our nursery is a container operation where we place all of our containers on polyethylene. Most of our beds drain into one of our ponds, along with any pathogens that are washed out of the containers. Therefore, recycling the water will distribute these pathogens over the entire nursery. While researching this problem, we found that many pathogens may be inherent in the water supply and that recycling the water can only increase the problem. Before considering chlorination, have the water tested to make sure that it is part of the problem.

Chlorine compounds have been used for the disinfection of water for 100 years, but how it works is still not fully understood. We chose the injection of Cl_2 gas as our method of chlorination.

The element chlorine exists as a gas at room temperature. It has a characteristic pungent odor, which can be detected at extremely low concentrations. It is greenish-yellow in color, 2½ times as heavy as air, and will seek the lowest point in the building if a leak occurs. Chlorine is neither explosive nor flammable but will support combustion. It is reactive with almost all elements and will form many inorganic and organic compounds. Dry chlorine (Cl_2 in the presence of less than 150 ppm H_2O) does not react with most metals, but in the presence of moisture it becomes highly corrosive. When chlorine gas is compressed, it forms a clear, amber-colored oily fluid that is