GREENHOUSE ENGINEERING

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Greenhouses can provide an excellent controlled environment for plant production, provided they are designed and operate efficiently. The greenhouse should provide uniform lighting, heating, and water to all plants or seedlings within the structure. Orientation, the structure itself, heating, and ventilation are key factors in having a successful greenhouse operation.

ORIENTATION

One of the first decisions is related to location of the facility. Convenience is obviously a major factor and the proximity to an abundant supply of quality water and electricity. A considerable amount of time will be spent in the greenhouse, so the facility needs to be readily accessible. An adequate water supply is extremely important; for example, to fill a water bed to a depth of 6 inches requires 3.74 gallons per square foot, or for a typical 30 X 100 greenhouse, 11,200 gallons of water are required.

Light is a major factor in plant production. The orientation of the structure will affect light uniformity in the growing area. A north-south orientation is generally best in South Carolina. This orientation minimizes the shading effect of structural members due to the movement of the shaded areas throughout the day.

Shading from outside structures, such as buildings or trees, should be avoided. Wind breaks can be beneficial, but they should not be so close as to shade the greenhouse.

THE STRUCTURE

Any number of structures are suitable for growing tobacco transplants. It really depends upon the grower's choice and how they plan to operate the facility. A wood frame structure covered with plastic can do just as good as a steel structure covered with glass.

Several materials are available for covering a greenhouse. A double layer of polyethylene is the most common, due to its durability, low cost, effectiveness, and ease of installation. Glass, acrylic, and polycarbonate provide better light transmission characteristics and are longer lived, but are much more expensive to install.

A double layer of polyethylene is the most common choice for greenhouses in South Carolina. Two layers are used to decrease heat loss through the surface. The outer layer is most often 6 mil, while the inner layer can be either 6 or 4 mil. Most greenhouse films are treated with an ultraviolet light absorber to extend the life of the film for several years. Untreated polyethylene will last only a few months when exposed to sunlight. It is necessary to keep the two layers separated to obtain the insulating benefits of the double layer. Keeping the outside layer taut also minimizes risk of wind damage.

HEATING

Adding heat to a greenhouse can protect plants from freezing, speed germination, and accelerate seedling growth. The amount of heat required depends primarily upon desired inside temperatures, the greenhouse covering materials, and the amount of air leakage. With a double layer polyethylene house that is reasonably tight, a furnace sized to deliver between 75 to 100

BTU's/sq ft/hr will be sufficient under most South Carolina conditions.

There are several ways to heat a greenhouse: space heat, radiant heat, and/or zone heat. Space heat is simply heating the air, which in turn heats the soil and plants. When heating is required, the air will be 10 to 12 degrees warmer than the soil. Heaters should be controlled by an aspirated thermostat located near the center of the greenhouse and near the growing area.

Radiant heat does not directly heat the air but heats the soil and plants directly. The air should be cooler in a radiant heated house, because the heaters should be controlled by soil temperature. In this system, the soil will be warmer than the air, which is exactly opposite from the space heated house.

In the field test in Florence County, when comparing radiant heat to space heat, the same amount of energy was used during the same time period, but plants in the radiant heated house grew much faster. The radiant heated house could have been started several weeks later than the space heated house, thus saving considerable energy in the early part of the season.

Zone heating implies adding heat just to the place where it is needed most. Heating the water in a float system or putting heat underneath benches will heat the root zone of the plants, which will increase the rate of growth. Adding heat to the water-bed system increased stem diameter and root mass of tobacco seedlings, but may enhance Pythium disease.

VENTILATION

Every greenhouse should be equipped with at least two air handling systems. One system is an air exchange system and may be drop sidewalls, or fans and louvers. If properly designed, natural ventilation can be effective but is more difficult to control. If the greenhouse is to be used during the summer months, it most likely needs to be equipped with exhaust fans that will deliver at least one air exchange per minute.

The second air handling system that should be in every greenhouse is for air circulation. Air circulation is important to maintain uniform conditions within the house, facilitate growing, and minimize disease losses. The circulation fans should be operated 24 hours every day unless ventilation fans are operating during the day. Continuous air circulation will minimize condensation problems.

The two systems currently being used for air circulation are the convection tube and the horizontal air flow (HAF) system. Either system will improve growing conditions and help produce a uniform crop.

The convection tube is a polyethylene tube that runs the length of the house and forces air through holes spaced along the tube. This system is best suited for houses that have a lot of obstructions. The HAF system circulates air within the house by having opposing fans on each side of the house to move the air in a circular motion around the perimeter of the house. The HAF system requires a little less energy to operate, and the initial cost is about the same as the convection tube system.

HUMIDITY CONTROL

Ever had dripping in your greenhouse? Large water drops can play havoc with young plants, and can cause disease problems! To do something about the dripping in greenhouses, there are two approaches to take. Either control the dripping, direct the drips to where you want them, or minimize the amount of condensation that causes dripping.

In order to make drops fall where you want them, it may be necessary to modify the greenhouse structure. The slope of the plastic and any component that intercepts the drop as it moves down the plastic will affect where it falls. The plastic on most Quonset structures has a flat section in the middle where drops form. When the drops get large enough, they fall along a wide band down the middle of the house. Drips also form where the plastic touches purling along the sides of the house. Moving the plants may be the best solution here because the drips are in a narrow band.

"No-Drip" plastic has a surface treatment that allows the condensate to move down the plastic before it forms into large drops. This feature does not help much in the middle of the house where the plastic is horizontal. However, it does allow drops to sheet off the sides of the greenhouse until they come in contact with something that will allow the moisture to consolidate and form a drip. So, there is some control over where the drips form in your greenhouse, or else move the plants out of the way of the drip.

The second approach at your disposal is to control the amount of condensate that collects on the surface of the greenhouse. Moisture drops will form whenever a surface reaches or falls below the dew point of surrounding air. This is the same principle that causes condensate on an ice tea glass in summer. The higher the relative humidity, the higher the dewpoint for a given air temperature. So, to control drips, either lower the relative humidity or raise the surface temperature of the plastic. Raise the surface temperature by blowing air across the surface. This is one of the benefits of providing continuous air circulation in the greenhouse. If there is a convection tube down the center of the house, turn the vent holes up so that the air washes across the plastic. Drips will likely not form where air strikes the plastic. This continuous air movement will minimize condensation, but it takes a lot of air to eliminate all condensation and for most situations it is nearly impossible. If the surface temperature cannot be raised, then relative humidity must be lowered to eliminate dripping.

The simplest method to lower relative humidity in cold weather is to bring in outside air and heat it. Heated air will absorb moisture, which can then be exhausted. There is a trade-off: the cost of heating the cold air versus the damage done by dripping. The best option may be to minimize the dripping by providing good air circulation and keeping the relative humidity as low as possible inside the greenhouse.

Often one of the overlooked factors in drop formation is timing of drop formation. The maximum radiation cooling occurs just after daybreak. At that time the plastic is losing heat at a maximum rate, or drop formation is fastest. The rapid drop formation is not just because of high humidity in the greenhouse, but also due to the rapid heat loss from greenhouse plastic. As soon

as solar gain in the greenhouse increases, the drop formation will cease. There will continue to be some dripping, but after the sun begins to warm the greenhouse, there will be no new condensate added to the drops. It takes time to evaporate all the water that is contained in the drops, depending upon the amount of solar radiation and humidity of the inside air.