Environmental Control Equipment

One of the greatest advantages of growing seedlings in a container nursery, is the ability to control all the environmental factors that are potentially limiting to growth. In fully-controlled propagation. structures, such as greenhouses, growers rely on environmental control systems to monitor and regulate all the climatic variables. There are three different types of environmental controls that vary considerably in sophistication and price **(Table 4).**

Discrete and dedicated controls. These single-function controllers (e.g. thermostats) regulate one piece of equipment with a simple ON/OFF switch. Currently, around 90% of existing greenhouses still rely on mechanical thermostats (Greenhouse Manager 1994a). One common thermostat contains a bimetallic strip that is sensitive to changes in temperature and activates a switch when it senses a change. Thermostats are used to regulate temperature control equipment, such as: heaters, fans, and vents **(Table 4).** Other types of discrete and dedicated controls do not sense the propagation environment at all, but use time clocks to regulate irrigation solenoids, photoperiod lights, or carbon dioxide generators. They can operate independently or be linked in sequence. This redundancy of function means that if one device fails, the rest of the system keeps working. Discrete and dedicated controls are inexpensive, but must be calibrated routinely. Thermostats are particularly unreliable, and response varies from instrument to instrument, and can also change over time.

Analog and integrated controllers. A wide variety of controllers are available that can regulate many different environmental variables **(Table 4).** They use proportioning thermostats and other electric sensors to gather information from the propagation environment, and then rely on electronic logic circuitry to process this information, make decisions, and operate a single piece of environmental control equipment. Analog controllers are limited to a single sensor, and can control only one propagation environment (Ball 1991). Many are "hardwired systems", which means that they are not directly programmable, whereas others have limited programmability. Analog controllers can also be wired to activate alarm systems, such as when the temperature decreases past a set point.

Environmental controllers are commonly linked to provide multiple functions, and operate in stages to maintain the desired temperature by switching an increasing sequence of heating or cooling. For example, consider a situation in a greenhouse early in the morning. Neither the heating nor cooling is operating; the house is in "neutral". As the greenhouse heats up, the temperature reaches the first cooling setpoint and one of several fans comes on. If that gives sufficient cooling, nothing further happens, but if the temperature continues to rise and reaches the second cooling setpoint, a second fan comes on. If all of the fans are on, and cooling is still not adequate, then the pump comes on and begins circulating water through the wetwall and evaporative cooling-the third stage of cooling. As the greenhouse cools down, the sequence reverses. Heating stages consist of a sequence of burners and heat distribution fans.

Climate control computers. The computer revolution has radically changed the way in which the environment in propagation structures is controlled. Climate control computers use microprocessors to combine information from a variety of sensors and provide an integrated view of all factors in the propagation environment. Computers can sense and record climatic information from an outside weather station, as well as atmospheric or growing medium conditions within the propagation structure **(Figure H).** Climatic indexes, such as vapor pressure deficit, used to be difficult to monitor in operational nurseries, but this task is now possible with computers **(Table 4).**

Computers are essential in high-tech greenhouses to integrate all the various environmental control equipment. Instead of only switching a single piece of equipment on or off, climate control computers can modulate, which produces an infinite number of adjustments. They also compile and analyze the full complement of environmental data to make "intelligent" decisions. For example, during the winter, light sensors tell the climate computer that

Table 4. Features of the 3 types of environmental controls

	Type of environmental controls		
	Discrete/ dedicated	Analog/ integrated	Computer system
Functions			
Multiple sensors	No	No	Yes
Multiple structures	No	No	Yes
Proportional switching	No	Yes	Yes
Seasonal adjustments			
Clock time	Maybe	Maybe	Yes
Solar time	No	Maybe	Yes
Weather stations	No	Maybe	Yes
Record and store data	No	No	Yes
Programmable	No	Limited	Yes
Price range	$50-250	$800-1,600	$3,000-50,000+
Environmental factors*			
Temperature	Heaters	Heaters	Heaters
	Vents	Vents	Vents
	Fans	Fans	Fans
		Wet Wall	Wet Wall
		Heat Curtain	Heat Curtain
Humidity	Humidistat	Heat	Heat
		Vents	Vents
		Mist Nozzles	Mist nozzles
Light	Time Clock	Lights	Lights
		Shade curtain	Shade curtain
		Blackout curtain	Blackout curtain
Carbon dioxide	Time Clock	Yes	Yes
Water	Time Clock	Irrigation	Irrigation
		Mist nozzles	Mist nozzles
Mineral nutrients	Ratiometric	pH	pH
	Injector	Salinity	Salinity
			Nutrients

*Note that each environmental factor requires a separate piece of discrete/dedicated equipment or a separate type of analog control and these must be integrated. Source: Ball (1991), Mackenzie (1993).

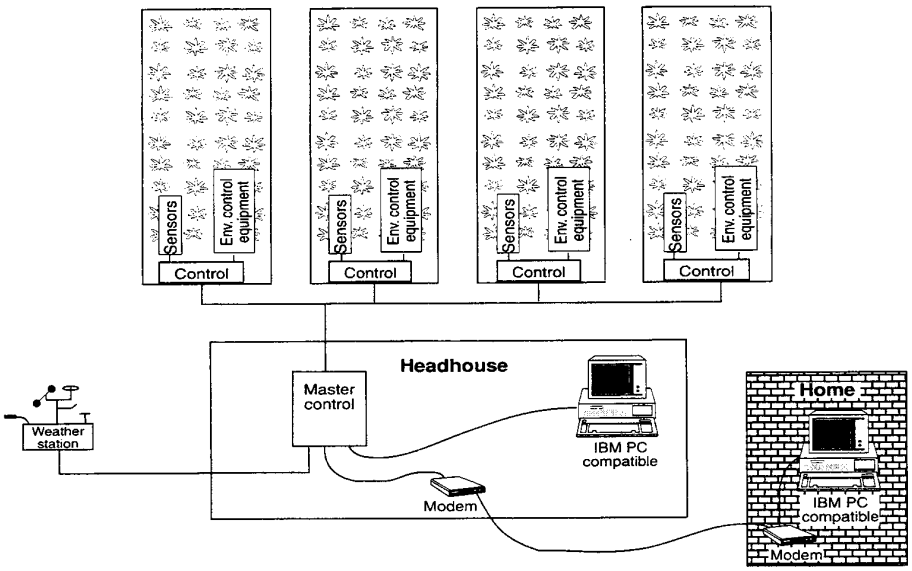

Figure H: Climate control computers monitor environmental conditions both inside and outside the propagation structures, and permanently record the data, and can be accessed from remote locations.

the sun is setting, therefore, the demand for heat can be anticipated before the temperature actually begins to drop. Increasing energy costs and concern about excess fertilizer runoff make computer control systems even more attractive. Documented energy savings can range from 15 to 30% for typical nurseries, and as high as 40 to 60% for high-tech greenhouses with all the latest equipment (Whitesides 1991).

A typical system consists of a central computer terminal, and individual controllers and alarms at different locations throughout the various propagation environments **(Figure H).** One terminal should be located in the headhouse so that personnel can instantaneously monitor all environmental factors in each propagation environment, as well as analyze stored data to compute trends and detect problems. Many growers also install computer terminals in their homes so that they can respond to potential problems without having to go to the nursery. One of the greatest advantages of climate control computers is that they are able to accurately record what really happens in the nursery so that this information can be used for troubleshooting and fine-tuning environmental control equipment. Computers also can be linked to a more sophisticated alarm system that can be redundantly programmed. With this technology, computers can often identify the location and nature of a problem, so that the grower is not needlessly bothered.

Nurseries with propagation structures larger than 2,000 m^2 (21,500 square feet) can usually justify computer control systems, which pay for themselves in 3 to 5 years (Mackenzie 1993). Computer systems come in many different models, offering a wide variety of different features. Developers should consult with other nurseries and suppliers to make sure that the system is well matched to their requirements. Maintenance is rarely a problem because replacement parts can usually be obtained by overnight courier, and companies offer specialist support by telephone.

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