invest in a computer controller and yet still need better control than is possible with timers.

A controller that uses light and temperature in combination with a timed mist on interval can provide excellent control that approximates ideal control. This controller can be economical to buy and will require very little maintenance. Light- and temperature-sensitive mist controllers provide for excellent mist control at a cost only slightly higher than time clocks. These controllers save valuable time for the propagator who no longer has to readjust the time interval several times a day or live with lower stands and less growth.

There are many excellent mist controllers presently available. We are preparing a listing of most of the readily available controllers. This listing will provide easy to follow comparisons among controllers and will detail most features and benefits. These comparisons with manufacturers' prices will provide a controller selection reference to guide you to the controllers that will best serve your needs. This "Controller Selection Reference" can be requested by writing to me, Bruce Moesel at the following address:

American Plant Products & Services, Inc.
9200 N.W. 10th
Oklahoma City, OK 73127
or call me at 1-800-522-3376 or 1-405-787-4833.

THE USE OF HUMIDIFAN IN PROPAGATION

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Research was begun in 1974 at the Hampton Roads Agricultural Experiment Station to minimize or eliminate the weaknesses found within accepted propagation practices. Eliminating the application of excess water and its resultant soaking and cooling of the propagation medium was the primary objective of this research. The result was the introduction of ventilated high humidity propagation.

THE CONCEPT OF VENTILATED HIGH HUMIDITY PROPAGATION

Ventilated high humidity propagation is a method of propagation in which cuttings are maintained under controlled temperature and humidity. Temperature is maintained at a determined point by controlling the amount of solar-heated air that is exhausted.

Humidity is maintained as close to 100 percent as possible by humidifying all incoming air. This method differs from non-ventilated high humidity propagation by having a means of controlling the temperature without lowering the humidity. It differs from misting by directly humidifying the air around the cutting instead of wetting leaf surfaces. Temperature and humidity control reduces the stress on cutting that occurs during intervals of high temperature or low humidity. Ventilated high humidity propagation requires the consideration of four factors on which it depends: 1) ambient air temperature and relative humidity, 2) humidification rate of incoming air, 3) rate of air exchange, and 4) air exchange among cuttings.

Ambient air temperature and relative humidity. Relative humidity is the amount of humidity relative to the maximum amount that air can hold at its existing temperature and pressure. Ambient air always carries some moisture. When ambient air is expanded by daytime solar heating, its moisture-carrying capacity is increased while the amount of moisture that it carries remains the same and relative humidity is decreased. When night air is cooled, it conversely contracts and is capable of carrying less moisture. The moisture it carries then becomes a larger percentage of its total capacity (increased relative humidity). If the percentage exceeds 100, the extra moisture condenses as dew. The temperature at that time is defined as its dewpoint. Therefore, humidifiers are not needed when the ambient air is near its dewpoint or during the night except during periods with unusual hot night winds.

Humidification of incoming air. Humidification occurs whenever unsaturated air comes into contact with water. Exposed water surface area is increased by dividing water into a multitude of fog-sized droplets of less than 50 microns in size. The duration of exposure is extended by carrying these droplets on an air current. Evaporation further reduces droplet size until the droplets remain airborne even in slowly moving air.

Droplets suspended in an airflow are unstable. They are produced by high-velocity movement and are subject to collision and uniting to form larger droplets until their speed is reduced. During cool weather droplets remain heavy longer which also increases their chances of collision. Larger droplets produced by collisions quickly settle and wet the cuttings. While some settling causes no problem, excessive settling should be avoided by reducing the water flow rate to the humidifier.

Technically, 10 to 20 gallons of water are required per hour to humidify each 1000 square feet of area. The smaller amount is adequate during cool weather and when the greenhouse is heavily shaded; 50 to 70% shading reduces the amount of heat generated during the summer season to manageable levels and still allows ample light for the cuttings. Heat reduction is necessary during the summer season but is not always advised for the winter season. During cool weather, ventilation may be stopped to reduce heat losses, but humidifiers must remain in operation at low rates to replace the moisture that condenses on greenhouse walls. Condensation can be reduced by using low humidification rates and by removing greenhouse shading to increase solar heating so that exhaust fans will operate.

Rate of air exchange. Solar radiation will heat a greenhouse 8 to 15°F higher than the outside air. The increase in temperature is higher during the summer season than it should be for growing plants. To cool a greenhouse effectively with a fan, the interior air must be exchanged approximately once per minute.

Humidification equipment cannot humidify completely at the rate of air exchange necessary for cooling. A greenhouse with 3000 square feet of floor space would contain approximately 35,000 cubic feet of air. An exhaust fan for humidifiers capable of humidifying 7000 cubic feet of air per minute would exchange the air once each five minutes. The cooling from evaporation during humidification combined with exhausting of hot air is adequate to cool the cuttings of a shaded greenhouse.

Shading reduces light intensity so that less heat is produced for the ventilation system to remove. Shading also moderates the temperature so that less readjustment of the humidification rate is required. The minimum amount of light needed for propagation is not well defined, but reduction of rooting has not been observed with as much as 80% shading.

Temperatures favorable for root initiation are not well defined. In general, increases in temperature favor root growth. Most species tend to tolerate temperatures below 90°F except poinsettia, cotoneaster, and pyracantha. These require slightly lower temperatures and show high-temperature damage as a buff color and brittleness of any new roots that do develop.

During cooler weather, a high rate of air exchange is not necessary and, if it is not lowered, excessive cooling will reduce root initiation. The exhaust fan should be thermostatically controlled so that it will not operate during cool and cloudy weather. Temperatures of the propagation medium will remain more favorable for rooting even when the humidifiers remain in operation.

Air exchange among cuttings. The most frequent failure in high humidity propagation is moisture stress resulting in leaf drop. It was common before mist and can be seen whenever humidification is not properly used. Humidification systems that do not provide for adequate circulation of humidified air among the cuttings function poorly because of the nature of solar radiation. The humidity is lowered by expansion of the heated air, which causes cuttings to wilt and leaves eventually to drop.

Ventilated high humidity propagation is successful only when circulation of air among the cuttings is adequate for removing heat generated from sunlight. Ordinary circulation fans move air at approximately 12 miles per hour and are inadequate for moving air the distance required for propagation. Increasing the humidified air flow to 30 miles per hour increases its effective circulation distance to approximately 35 feet.

By slowly oscillating the humidifier in a horizontal arc over the cuttings, the humidified area is greatly increased. Since air movement for ventilation moves from one end of the greenhouse to the other, the arc of oscillation is more effective if it does not circulate against the ventilation airflow. Humidifiers placed at the edge of the greenhouse efficiently circulate over 90 degrees and, when placed at a distance from the edge, 180 degrees.

In the most advantageous positions, one humidifier is capable of circulating humid air over approximately 1000 square feet of floor space. Under heavy shading or during cold season, circulation of humid air among cuttings does not need to be as thorough. The area capable of humidification by one humidifier is less clearly defined, but may be extended to twice or three times this area.

A HUMIDIFIER FOR VENTILATED HIGH HUMIDITY PROPAGATION

When this research was started in 1974, satisfactory humidifiers for propagation were not available. During 1978, research was begun to develop a satisfactory humidifier for ventilated high humidity propagation. The resulting humidifier is the Humidifan (Figure 1).

Humidifan is a high-capacity humidifier designed for efficient and dependable operation. It disperses as much as 40 gallons of water per hour as fog in an airflow that is essentially laminar, the type best suited for carrying water dispersed as fog-sized droplets. An oscillator directs this flow in an arc, which is adjustable up to 360 degrees and is capable of covering at least 1000 square feet of area when properly located.

There are three requirements for setting up ventilated high humidity propagation:

1. a fan-ventilated greenhouse
2. greenhouse shading
3. Humidifans

Ventilated high humidity propagation is a new concept based on a limited amount of research. While it has been used successfully under a variety of conditions, some conditions remain that have been untried. An efficient and common nursery greenhouse is the 30-by-100 foot plastic-covered quonset greenhouse. Ventilated high humidity propagation is easily set up in this type of greenhouse.

The fan-ventilated greenhouse. The rate of air exchange must be reduced to match the humidification rate more closely. Either a

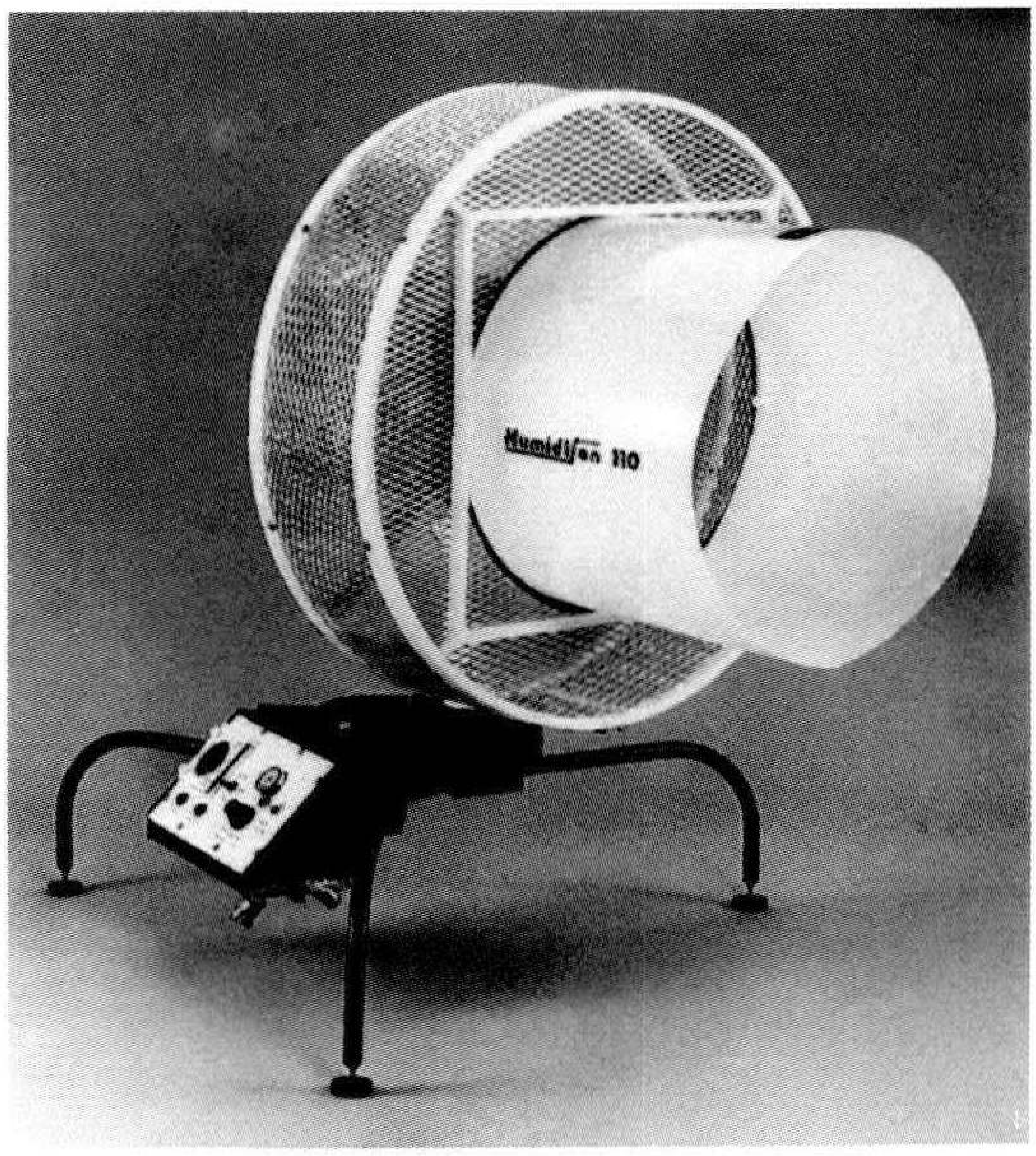

Figure 1. The Humidifan is designed specifically for ventilated high humidity propagation.

small fan capable of exhausting approximately 7000 cubic feet of air per minute can be installed or an existing fan can be partially blocked to allow only this amount of air to be drawn through it.

Shading of the propagation greenhouse. Fifty to 70 percent shading material has been used to reduce midsummer solar radiation. The area near the wall is difficult to humidify, therefore shading should extend to the ground level to minimize problems in this area.

Installing Humidifans in the greenhouse. Humidifans can be located in two patterns for propagating within the entire area of a 30-by-100 foot greenhouse. One pattern is to locate Humidifans at 33-foot intervals along the centerline of the greenhouse starting at the intake vent (doorway at the opposite end of the exhaust fan). Fans are operated in a 180-degree arc. The other pattern is to locate Humidifans at 33-foot intervals on alternate sides from each other beginning at an intake-vented corner. In this pattern, Humidifans are operated in 90-degree arcs. In all positions Humidifans should discharge their air flows in the direction of ventilation or not more than 90 degrees away from it. During midsummer these patterns will provide the best results.

Under heavy shading, during cool weather, or when propagating relatively hard cuttings, the range of coverage can be extended considerably. A compromise is to extend the range of the fans to 50 feet by increasing flow rate. However, the overloading increases the wetting near the humidifier.

Ventilated high humidity propagation is a new method of propagation that is proving to be both reliable and versatile. It offers a good alternative method of propagating that will develop cuttings into vigorous and healthy plants.

COMPUTER CONTROL OF IRRIGATION SYSTEMS

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Irrigation is for the purpose of maintaining an adequate water supply within the active root zone. In order to maintain the soil water system within acceptable bounds it is first necessary to estimate the present state of the soil-water system. The estimation may be made indirectly by maintaining a budget of available water or directly by measuring soil-water content distribution or a closely related variable (4). Changes in the state of the system are made by manipulating the irrigation system so that water is applied at the proper time and in the proper quantity as established by some irrigation management policy.

The objective of this work was to develop a digital computer control system (DCCS) as an aid for irrigation system management such that: 1) its cost is of the order of magnitude of a low-cost microcomputer; 2) all system components are readily available from local outlets, or they are low cost so that they can be kept in stock; and 3) the system operates in manual, timer, and direct digital-control modes. The system should be simple to operate and flexible in order to meet the demands of a controlled production system.

DIGITAL COMPUTER CONTROL SYSTEM

Hardware components. A block diagram of the components of a DCCS system are shown in Figure 1. At one end is the soil system and at the other is the computer system. The computer system acquires information about the soil system through an analog front end, here exemplified by a single sensor. Acquired data is processed by the computer system, and any necessary actions are carried out through an output subsystem, here exemplified by a single-controlled solenoid valve.

A DCCS was developed based on a low-cost home computer using readily-available components for both the analog front end and the output subsystem (7). The characteristics of each component are the following: