ADVANCES IN HUMIDITY MEASUREMENT

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New methods for humidity measurement are beginning to open the way to precision humidity control in greenhouses.

Humidity in greenhouses is one of the more difficult environmental factors to measure, let alone control. The standard procedure for years has been to compare the temperature of an evaporating surface (wet bulb) with the actual air temperature (dry bulb) to arrive at the relative humidity — or, the ratio between how much water the air can hold at the wet bulb temperature, and the actual amount present. These wet bulbs have always had problems. To accurately measure humidity, using the "psychrometric" method requires adequate ventilation, distilled water, clean wicks and good, accurate, matched temperature sensors. Obviously, these must be maintained, preferably every day, depending upon the size of the water reservoir. That maintenance usually goes by the board when a grower gets busy around holidays. The inherent limitations in most temperature measuring systems (plus or minus one scale division usually) means that one is seldom closer to the real humidity than ± 15% RH (relative humidity). If one uses some of the desk-top devices with two degree divisions, they can be more than 30% RH in error. Cheapies, readily available in hardware stores, are usually not worth the powder to blow them up.

In the last five years, new devices known as capacitance probes have been developed that provide a linear output voltage with relative humidity between 0 and 100% **(Fig. 1).** There are at least two companies in the U.S. that advertise these probes with appropriate read-out devices. Our first one, bought two years ago, was a Finnish model and very expensive (over $1,000.00). Our most recent model is British and can be purchased for under $200.00, depending upon the rate-of-exchange. The device in Fig. 1 carries all the electronics in an eight-inch handle with zeroing and span controls in the base. They do require a 12 volt DC supply, which is why one usually purchases them with a read-out combined with the power supply. They function by means of a polymer which is in equilibrium with the water vapor in the air, and the electrical capacitance changes accordingly. Because of their very small size, their response time is rapid, and so far, they have performed very well under our conditions. For the first time, we are going to use one for outside humidity measurement since they are rated for below -40 F. Calibration capsules can also be purchased from a number of companies, using saturated salts.

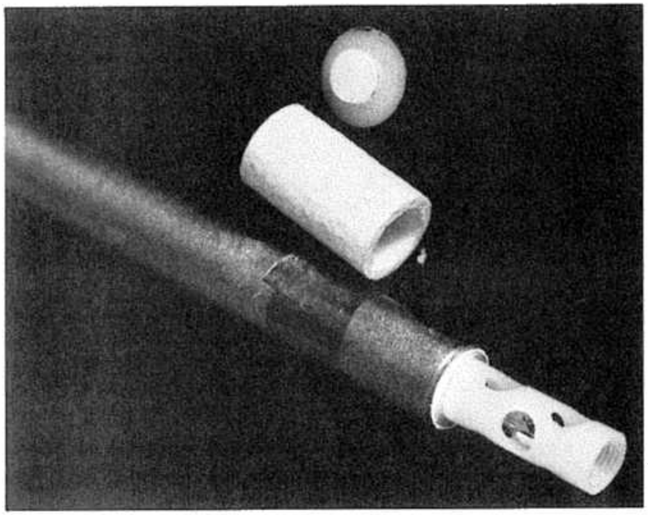

Fig. 1: Modern, capacitive type humidity probe with its filter. On the basis of preliminary experience, the probe, with all electronics contained in the handle, appears much more accurate and responsive than the traditional wet bulbs, or much more expensive dew pointers. This particular device is British origin and may be purchased for under $200.00. Calibration is simple, and does not require the care needed by wet bulb systems.

This considerably simplifies calibration checks, and one does not have to measure temperature. Most probes also have a platinum resistance temperature detector next to the capacitor. With the temperature read-out, one can calculate actual vapor pressure (concentration) from RH and a dry bulb reading.

In our computer control system, we use these probes in a central, aspirated unit in each greenhouse, and calculate the actual concentration of water vapor in air (units are millibars, 1019.3 mb at sea level pressure). Since the amount of water air can hold is directly dependent upon temperature **(Fig. 2),** a measure of relative humidity (a human com-

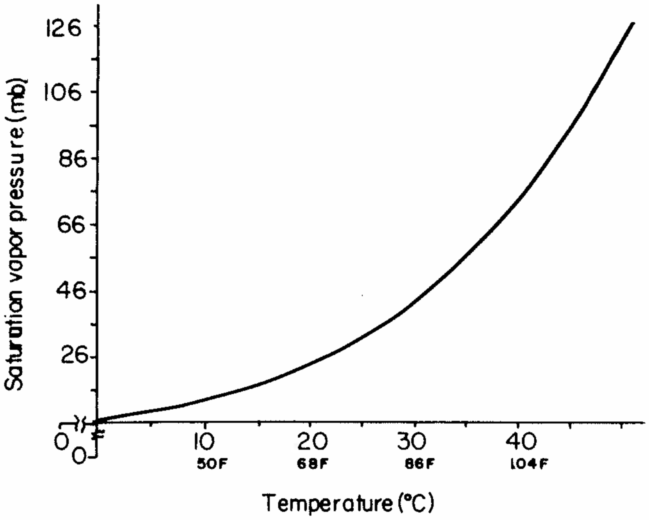

Fig. 2: The relationship between the amount of water air can hold at saturation and air temperature. Concentration is given in terms of "partial pressure." This is millibars although psi, Kilograms per sq. cm. or Pascals could be used. Atmospheric pressure at sea level is 1019.3 mb or 14.7 psi.

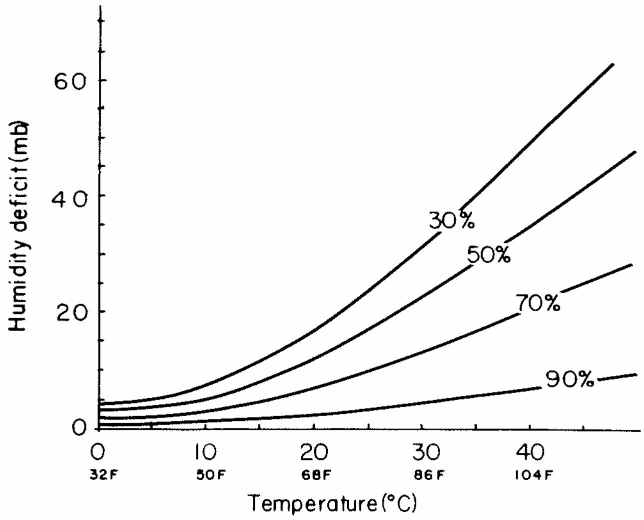

Fig. 3: The relationship between air temperature and "humidity deficit" (the difference between actual water concentration and what the air could hold at saturation) for various relative humidities. The points to be made are that: 1) The term "relative humidity" does not tell one how *much* water is present, and 2) RH does not state the amount of stress on the plant except in very general terms.

fort index) is not always a good indication of the stress to which plants in greenhouses are being subjected. The rate of water loss from plants is directly determined by the difference in water concentration between inside and outside the leaves. If we assume, for any well watered crop, the internal leaf humidity is 100% RH, then water concentration inside the leaf is directly dependent upon leaf temperature. If we know what the outside vapor concentration is, we can calculate the difference. Our computer system calculates the concentration difference between what the air can hold at saturation at the particular dry bulb temperature and what is actually present, based upon the reading from the capacitance probe. It can be noted in **Fig. 3,** that basing humidity control on relative humidity, means that the actual humidity deficit changes with temperature at any constant relative humidity. In a sense, we feel we have simplified the control aspects of humidity. The relative humidity may vary quite widely, but the actual plant stress tends to remain constant, provided we have the equipment to add or extract water from the greenhouse. Note also, that at temperatures below 50 F, differences in actual humidity deficit (difference between saturation and actual) are relatively minor, and whether one controls at 30% RH or 90% RH is not all that remarkable. At dry bulb temperatures much above 86 F, however, the ability of the air to retain water at saturation increases rapidly, so that the humidity deficit at 30% RH is much different from the humidity deficit at 50% RH. Accordingly, it is possible for the system to control at 50% RH if the air temperature is at 50 F, but at 90% RH if the air temperature is above 86 F, based upon an acutal humidity deficit. For cool growing crops, humidity control is less important than control for warm crops.

Another factor is that it becomes possible, with remote sensing, infrared thermometers to actually sense plant temperature. If the plant temperature approaches the dew point — based upon actual concentration of water in the air — a dehumidification cycle can be initiated with little difficulty in a computer climate control system. It is simply a few additional lines of code. This can provide very effective disease control.