RUTGERS COOPERATIVE EXTENSION

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Principles of Evaluating Greenhouse Aerial Environments
Part 1 of 3

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Introduction

Successful production depends on growers providing a suitable environment for the plants. The aerial environment in greenhouses is a key component in the success of these facilities. But what makes one indoor environment better than another? Specific test instruments allow an objective evaluation and quantification of environmental parameters. Instruments may be used to troubleshoot the ventilating, heating, and cooling systems that influence the greenhouse environment. Instrument readings can be compared to recommended environmental conditions. As always, instruments must be used properly to obtain values that truly represent the production system. This fact sheet provides general principles for proper evaluation of the aerial environment in greenhouse structures. An emphasis is placed on the use of hand-held instruments for a "spot check" of the environment and ventilation system. The principles are equally valid in other plant production spaces such as germination chambers, propagation rooms, and growth chambers.

Temperature is the most easily measured aerial environmental parameter. However, each plant species has its own optimum range and timetable for features such as productivity, flowering, and timing to market. Other commonly measured characteristics related to plant production include humidity, light level, ventilation rate, air speed, and carbon dioxide concentration. These parameters are fairly easily measured and are needed to more fully characterize the plant environment. An evaluation of the indoor environment must emphasize the air space directly surrounding the plants.

Contaminant gases and dust concentrations may be a problem in some environments but are less easily quantified. Contaminant gases include carbon monoxide [CO], nitric oxide [NO] and nitrogen dioxide [NO_2] that may be released from a heating system or ethylene which is a by-product of plant metabolism. Finally, airflow visualization is a useful tool to evaluate air distribution from a ventilation system.

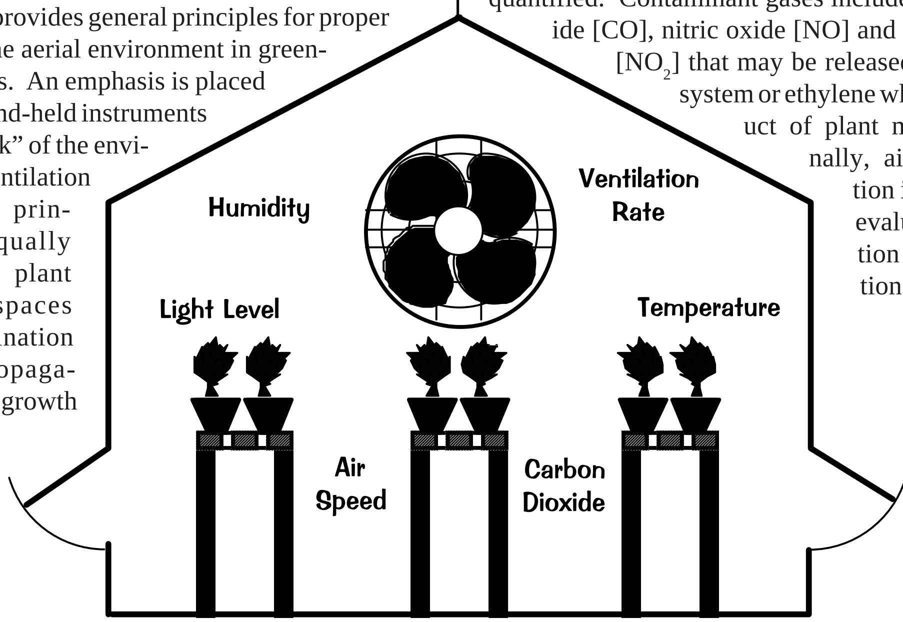

Figure 1. Greenhouse environment can be quantified and improved through the thoughtful use of instruments that measure characteristics important to successful plant production.

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Principles of Aerial Environment Measurements

1. Measure in the right place. It is important to measure the characteristics of air that the plants are exposed to, in addition to the air moving around them. Usually environmental control sensors used in daily management, such as thermostats and thermometers, are located for human convenience at head level. Get close to the plants and make some subjective evaluations within the plant canopy before taking measurements. Notice if there are variations in conditions experienced by the crop. Note any conditions such as health problems at the top versus the bottom of the crop. Look for consistent problems near edges of benches or in certain areas of the greenhouse such as near a heater or evaporative cooling pad. Find a pattern to the variation in conditions around the greenhouse. Air characteristics such as temperature, humidity, and particularly levels of contaminant gases such as carbon monoxide and ethylene can vary greatly within a greenhouse. Compare measurements taken in different locations throughout the production facility. Include nursery and storage areas if appropriate. Decide what it is that you want to measure, where you want to measure, and position the instrument accordingly.

2. What is the instrument measuring? The instrument can only read what it is exposed to. Be aware of what part of the instrument does the sensing. Installing an instrument within an environment can alter the conditions immediately adjacent to the instrument. For example, positioning an air velocity meter in the jet of air exiting a fan disturbs that air by forcing it to go around the meter. The measured velocity represents a disturbed airflow. Often this effect cannot be completely avoided. Avoid standing directly in the air jet exiting a fan since your body adds a large obstruction to airflow; instead stand to the side of the fan away from the air jet. Similarly, a temperature probe positioned in direct sunlight will indicate a higher temperature than a probe positioned more appropriately in shade or inside an aspirated box (Figure 2).

3. Understand how the instrument works. By understanding basic principles of how an instrument detects air characteristics, instrument troubleshooting becomes easier when odd readings are obtained. A reading is only as good as the understanding that went into determining it. For sensitive instruments, determine if fluctuating readings are a natural part of the environment being characterized or part of the instrument measuring mechanism. Find out how long it takes the instrument to determine and display a stabilized reading.

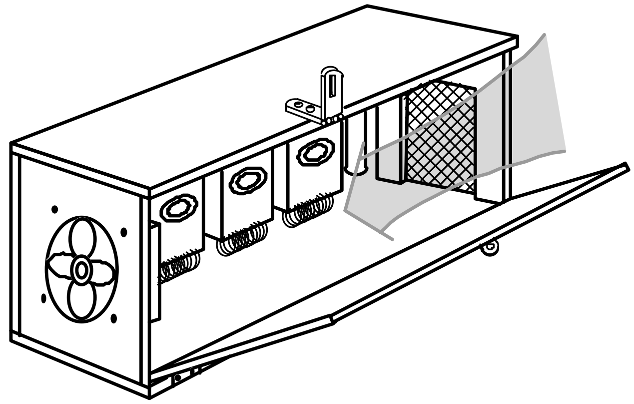

Figure 2. An aspirated box is recommended for shielding permanently installed greenhouse sensors from solar heat gain.

Greenhouses can be too dusty and humid for some precision instruments to work properly when installed permanently. For example, instruments that measure humidity change by the expansion and contraction of fibers are unreliable in most greenhouses. Some instruments may work properly when new, but then go out of calibration with the accumulation of dirt or corrosion. Be able to diagnose such problems by understanding how the instrument measures and by comparing it with another instrument. Calibration and maintenance of a correct calibration over time is one of the responsibilities of instrument use. Hand-held instruments may be brought in to determine the accuracy of permanently installed instruments and to take readings at additional locations.

4. Question each reading. Determine if the reading makes sense in the environment being considered. Take more than one reading. A set of three readings at one location often is necessary to confirm that sporadic measurements are reliable. Due to gusty conditions, air velocity measurements may never settle down into one distinct reading, so a range of readings should be averaged.

5. Record readings and observations. Summarize the results and observe if there is a pattern. Notice if measured conditions correspond to an observed or perceived problem. Be sure to include conditions that affect the plant production environment, such as season, outside weather conditions, plant density, management practices, and stage of the crop. Growing conditions change during the day and from season to season. It may be necessary to use a recording instrument, a maximum-minimum instrument, or simply more than one "reading session" to correctly characterize an environment.

Now What?

Once measurements are taken, the resulting data should be compared to desirable conditions. Improvements to the growing environment can then be pursued with more certainty about current conditions and future achievements. Desirable aerial characteristics depend on plant species and development stage. Within greenhouses, usually a range of temperature is acceptable. Frequently, contaminant gases and humidity need to be kept below a threshold. For young plants, air speed is reduced to avoid chilling, while during hot weather a minimum desired air speed will be required for cooling or carbon dioxide replenishment for fast growing plants.

Summary

With proper use of instruments, environment conditions can be monitored for improvement. Understanding how the instrument obtains its reading is one key to successful troubleshooting of the environment. It is important to monitor conditions near the crop. One measurement goal is to determine where and why variability in conditions exists. Compare current conditions to recommended conditions for the plants being grown. Improvement to the environment can then be made and quantified with additional instrument measurements.

Additional Resources

Penn State/ Rutgers Fact Sheets

Instruments for Monitoring the Greenhouse Aerial Environment [I-41] Penn State
Evaluating Greenhouse Mechanical Ventilation Systems [I-42] Penn State
Instruments for Monitoring the Greenhouse Aerial Environment [E276] Rutgers University

Greenhouse Environment Guidelines

Greenhouse Engineering, NRAES-33. 1994. Aldrich, R.A. and J.W. Bartok. NRAES, Ithaca, NY. 212 pp.*
Proceedings of the Greenhouse Systems, Automation, Culture and Environment (ACESYS I) Conference, NRAES-72. 1994. NRAES, Ithaca, NY. 393 pp.
The Commercial Greenhouse, second edition. 1996. Boodley, J.W. International Thomson Publishing. Albany, NY 12212. 612 pp.*
Greenhouses, Advanced Technology for Protected Horticulture. 1998. Hanan, J. J. CRC Press, Boca Raton, FL 33431. 684 pp.
Plant Growth Chamber Handbook. 1997. R.W. Langhans and T.W. Tibbitts. Iowa Agriculture and Home Economics Experiment Station Special Report No. 99. Agriculture Information Services, 304 Curtiss Hall, Iowa State University, Ames, IA 5001-1050. 240 pp.
Greenhouse Operation and Management, fifth edition. 1998. Nelson, P.V. Prentice-Hall, Upper Saddle River, NJ 07458. 637 pp.*

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