Web site: http://aesop.rutgers.edu/~horteng

CCEA Newsletter

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CCEA is a research organization dedicated to the improvement and vitality of the Controlled Environment Agriculture Industry. CCEA is funded by Industrial and Grower Partners who contribute a yearly partnership fee. Satellite partnership is also available to growers. Information about **CCEA** is available from:

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In this issue:

This spring, an Easter lily crop is being grown in the open-roof greenhouse.

Vision Statement
CCEA, The Center for Controlled Environment Agriculture of NJAES at Rutgers University, a partnership among growers, industry, and researchers, will devote itself to research and transferring information required for an economically viable and environmentally aware controlled environment agriculture industry. We will particularly strive to identify future trends, critical issues, appropriate emerging technologies and provide leadership for opportunities which challenge world-wide controlled environment agriculture in the 21st century.

Overview of Current Research Projects

1. Modeling Natural Ventilation in Open-roof Greenhouses

Collaborators: S. Sase, E. Reiss, A.J. Both

Open-roof greenhouses are extreme natural ventilation systems: the entire roof opens up so that the indoor temperature is able to closely track the outdoor temperature. Even efficient mechanical ventilation systems frequently operate at a higher indoor temperature compared to outdoor conditions during periods with high solar irradiance. For open-roof greenhouses, little energy is required to change the position of the roof segments and, at high sun angles, sunlight is able to penetrate the structure without encountering any obstructions (greenhouse structure, glazing material, equipment, etc.). Thus, plants can be acclimated to favorable outside conditions without growers having to physically move them, and when conditions become unfavorable, only simple roof closure is needed to "bring" the plants indoor. Especially spring bedding plant growers are widely adopting open-roof greenhouses.

A computer simulation model for natural ventilation in open-roof greenhouses was developed to help predict the ventilation performance. The model predicts ventilation rates and temperature differences between inside and outside, based on weather (including internal net radiation and wind velocity) and structural conditions (height and opening area of the roof). The ventilation rate was calculated from thermal buoyancy (chimney effect) and wind forces (creating small air pressure differences around the greenhouse). A sensible heat balance was incorporated to calculate the ventilation rate and the temperature difference simultaneously. Using observed outdoor and greenhouse conditions, the model parameters were calibrated statistically. Not unexpected, it was shown that the internal temperature rise depended on the roof configuration as well as solar radiation and wind velocity. The model was developed based on data collected in an empty greenhouse. Further studies are underway to verify and possibly adjust the model to account for the effects of a crop canopy on the greenhouse environment.

A paper was published (see CCEA Newsletter of July 2002: 11(3)):

Sase, S., E. Reiss, A.J. Both, and W.J. Roberts. 2002. A natural ventilation model for open-roof greenhouses. ASAE paper No. 02-4010. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA. NJAES Paper No. P-12232-04-02. 9 pp.

2. Crop Production on Ebb and Flood Floors

Collaborators: G.J. Wulster, E. Reiss, A.J. Both

The ebb and flood irrigation system in the open-roof greenhouse consists of two independently operated growing sections (24 by 45 feet each) and is a so-called closed system: the nutrient solution used for an irrigation cycle is stored in an underground tank, pumped out onto the growing area through holes in the floor connected to an underground piping system, and the unused solution is then returned to the tank after each irrigation cycle. Make-up water and nutrients are added using an injector system. At the moment, no filter system is used to screen the returning nutrient solution, but this could be added at a later stage.

So far, two crops have been grown on the ebb and flood floor: chrysanthemum and poinsettia. During the poinsettia trials (using the cultivars Freedom Red, Peterstar Red, Red Velvet, and Plum Pudding), a growth regulator (Bonzi) was added (at the low rate of 0.5 ppm because residuals could remain in the nutrient solution) to one of the nutrient solution tanks. The results showed reductions in plant height and especially bract size, the extent of which varied with cultivar (Freedom Red was most affected, Red Velvet the least). Currently, a crop of Easter lilies is grown in the open-roof greenhouse (see picture on Page 1).

Crop production trials are on-going and no results have been published to date.

3. Floor Heating

Collaborators: E. Reiss, D.R. Mears, A.J. Both

Advantages of floor heating systems include the highly uniform temperature distribution across the floor, the heat storage capabilities, and the added insurance this stored heat can provide during a heating system malfunction. A typical floor heating system was installed in the open-roof greenhouse. Warm water (up to 120°F) is pumped through 7/8-inch (22 mm) plastic pipes located in the 4-inch thick solid concrete floor at 12-inch centers. The floor heating system is estimated to provide 20-30 Btu per hour per square foot of floor area. Warm water is supplied by a natural gas-fired hot water boiler, which also supplies hot water (approximately 180°F) to perimeter and overhead heating loops (fin pipes) that provide the remainder of the greenhouse heating requirement.

Several temperature sensors and water flow meters are installed in the heating pipes so that the amount of heat delivered can be calculated for each of the various heating loops. These calculations will allow us to document the overall contribution of the floor heating system to the entire heating requirement of the greenhouse. In addition, radiation and temperature sensors are used to calculate a total energy balance for the greenhouse. All these measurements and calculations are used to understand the various heat flows in and out of the greenhouse under varying outside conditions.

At the same time, we are starting to investigate control options for the floor heating system. Because typical greenhouse floor heating systems respond slowly to changes in the supply water temperature, it becomes important to anticipate changes in factors that affect the desired greenhouse temperature (e.g., absence of sunlight after sunset, colder outdoor temperatures at night, etc.). But how far ahead do we need to anticipate these changes? Is it possible to control a floor heating system effectively by placing a single temperature sensor in one of the plant pots positioned at a representative location on the floor? Which supply water temperature(s) should be used so that a grower can use a floor heating system most economically?

The work on floor heating is on-going and no results have been published to date.

View inside the open-roof greenhouse with a young chrysanthemum crop placed on the floor heated, ebb and flood irrigation system. The ebb and flood irrigation system collects and reuses the nutrient solution after each irrigation cycle, minimizing the environmental impact of this greenhouse production system.

View inside the open-roof greenhouse with the same chrysanthemum crop. Note the shadow patterns on the crop. These shadow patterns are caused by the greenhouse structure and roof glazing (double polyethylene) and move across the canopy as the sun changes position in the sky.

NJ Greenhouse Survey

Collaborators: R.G. Brumfield, G.J. Wulster, and A.J. Both

Rutgers Cooperative Extension is conducting a NJ greenhouse industry survey this spring. We have mailed the survey to the approximately 375 greenhouse growers in the state. The goals of the survey are to provide information about the economic situation of NJ growers, as well as determine what important issues are impacting our industry. With the data provided by the survey, we plan to organize an extension meeting where extension agents and growers will be presented with useful information to help them address the most pressing industry challenges. We plan on inviting several experts and ask them to present workable solutions. Funding for this survey was provided by a grant from Rutgers Cooperative Extension through the Department of Extension Specialists. A copy of the survey questionnaire can be downloaded from our web site (see link on the main page): http://aesop.rutgers.edu/~horteng

Mechanical Ventilation Fact Sheets

The following fact sheets are now available through Rutgers Cooperative Extension:

- Evaluating Greenhouse Mechanical Ventilation Systems (E277)
- Instruments for Monitoring the Greenhouse Aerial Environment (E276)
- Principles of Evaluating Greenhouse Aerial Environments (E275)

These fact sheets can be ordered from the RCE Publication and Distribution Center (732-932-9762) or can be downloaded by visiting the following web site: http://www.rce.rutgers.edu/pubs/

Greenhouse Glazing Workshop on the Web

In October 1998, CCEA organized the Greenhouse Glazing and Solar Radiation Transmission Workshop. Participants received a publication containing the text of a series of lectures presented during the workshop. The (edited) text of these lectures is now available on our web site (http://aesop.rutgers.edu/~horteng) by clicking the link to Presentations, followed by a link to the Greenhouse Glazing Workshop.

Lecture 1
Components of Radiation Defined: Definition of Units, Measuring Radiation Transmission, Sensors
Dr. Gene A. Giacomelli, Department of Agricultural and Biosystems Engineering, University of Arizona

Lecture 2
Plant Physiology: Environmental Factors and Photosynthesis
Dr. Dennis Decoteau, Department of Horticulture, The Pennsylania State University

Lecture 3
Glazing Materials, Structural Design, and Other Factors Affecting Light Transmission in Greenhouses
Professor Emeritus William J. Roberts, Bioresource Engineering, Rutgers University

Lecture 4
Greenhouse Glazing Effects on Heat Transfer for Winter Heating and Summer Cooling
Dr. David R. Mears, Bioresource Engineering, Department of Plant Biology and Pathology, Rutgers University

Lecture 5
Plant Physiology: Manipulating Plant Growth with Solar Radiation
Dr. Dennis Decoteau, Department of Horticulture, The Pennsylvania State University

Lecture 6
Differences among Light Transmission Tests within the Laboratory, within Short and Long-Duration Studies, on Artificial Testing Stands, and within a Greenhouse Structure with a Plant Crop
Dr. Gene A. Giacomelli, Department of Agricultural and Biosystems Engineering, University of Arizona