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Technology Transfer

Curriculum/Program Development *(T.H. Short)*
An economic development program was organized for hydroponic vegetable production in NW Ohio through the ABE Center, Bowling Green, Toledo Botanical Gardens (TBG), and the Lucas Co Extension Office. Wooster FABE provides technical support for the effort via Internet. Monthly study group meetings are held at TBG and a 2-day workshop was organized and coordinated for 40 participants at the annual OVPGA Conference in February (2002) in Toledo.

Decision Support for Hydroponic Vegetable Growing *(T.H. Short)*
Ohio has a program to develop hydroponic tomato production systems in NW Ohio Under T.H. Short's leadership. The growth and success of the venture is based on Extension support, crop production demonstration and education at Toledo Botanical Gardens and support decision support information via the Internet for both growers and support persons. Internet information has been developed and refined by an information systems engineer on the OSU/OARDC Wooster campus. A web site of the hydroponic tomato interactive program can be found at http://www2.oardc.ohio-state.edu/hydroponics/ tomatoes. Economic analysis programs that are interactive have also been developed for tomatoes and lettuce.

Equipment/ Sensors/ Control Systems

Automated Plant Monitoring *(P.P. Ling)*
A fully automated plant-monitoring platform has been developed for plant stress detection and control studies (Kacira and Ling, 2001). Advanced sensing technologies including infrared thermometry, digital imaging, and multispectral have been evaluated for drought stress detection. A rugged field sensing and control unit was also designed, constructed, and evaluated for continuous monitoring of plant drought stress in a greenhouse environment. The system has been used for irrigation management based on measured Crop Water Stress Index (CWSI).

Workshops/Colloquia/Symposia

Peter P. Ling. 2/27-2/28/01. Greenhouse Engineering Workshop – Environmental Control. Wooster, OH 44691. This 2-day workshop attracted 55 participants from 10 North American states/provinces.

Current Projects (individual and Cooperative Interdisciplinary)

Automation-Culture-Environment Systems (ACESYS) for Controlled Environment Production *K.C. Ting*

Controlled environment bio-production systems frequently exhibit the integration of automation, biological culture requirements, and environmental control (i.e. the concept of ACESYS). The ACESYS concept has been used in guiding the process of object-oriented analysis, design, and programming in the development of computerized systems analysis tools. A Visual Basic software program, PACCS, was developed to aid NASA personnel in planning, design, and operating biomass production components for advanced life support systems (ALSS). PACCS integrates mathematical crop models of simulated controlled environment hydroponic production of wheat, soybean, and white potato with scheduling and analysis tools. Analysis options allow for studies on the feasibility of growing multiple crops in shared environmental zones and sensitivity of off-nominal environmental conditions on desired crop production schedules. A model-based predictive controller was included in PACCS to compensate for environmental disturbances in the production system. An effort has been made to develop a top-level model of a food processing and nutrition (FPN) subsystem within ALSS. The FPN model was designed to make use of existing nutritional data, menu cycles, and related food processing information to study the effectiveness of the FPN subsystem. The main performance indicators for a FPN subsystem are the required mass and volume, the amount of ingredient usage, crew time requirements, waste generation, energy consumption, and heat generation from food processing. The model is useful for studying "what-if" type scenarios. The model has been implemented using a JAVA programming platform. The ACESYS concept has also been used to develop computer models for other ALSS subsystems including crew and waste processing/resource recovery. A top-level overall ALSS model is currently under development by integrating all the subsystem models.

Computational Fluid Dynamic Modeling of Natural Ventilation (*M.F. Brugger*)

The computational fluid dynamics (CFD) model continues to be an excellent tool to evaluate natural ventilation design of greenhouses. A returning faculty member, has picked up the lead in the greenhouse ventilation modeling. One reservation in the use of CFD has been the verification of modeling results. To better evaluate the reliability of results, a literature review and an evaluation of the parameters used in the modeling process were initiated. A new computer was obtained to facilitate quicker modeling.

Drought Stress Detection *(P.P. Ling)*

Plant-response-based closed-loop plant production is a concept of using a plant's physiological status as a feedback to adjust environmental and cultural practices to improve plant growth and development. Peter Ling is leading the effort to develop effective water management techniques for controlled environment plant production. During the past year, the project focused on (1) establishing an automated sensing and control platform for plant stress detection studies, (2) evaluating advanced sensing technologies for non-contact, early drought stress detection, and (3) evaluating the feasibility of monitoring plants in greenhouse environments.

Early, non-contact drought stress detection is a key to effective irrigation management for plant production. Timely, demand-based irrigation helps to improve water usage efficiency and crop quality. Delivery of water only as needed can also reduce runoff and leaching problems associated with over-watering. Drought stress detection techniques have been evaluated in greenhouse environments and show promising results.

Landscape Nursery Crop Engineering *R.C. Hansen*

We continued to evaluate the capability of our OARDC Fertigator to precisely deliver water and nutrients to 240 willow trees in our Landscape Nursery Crop Engineering Laboratory during Year 2001. An experiment was designed in collaboration with Dr. Dan Herms, Department of Entomology, OARDC, Dr. Carolyn Glynn, The Forestry Research Institute of Sweden, Professor Stig Larsson, Swedish University of Agricultural Sciences, Professor Robert Fritz, Vassar College and Associate Professor Colin Orians, Tufts University to grow willow trees potted in 2-gallon containers using computer-controlled fertigation during the summer of 2001. Preliminary results showed an inverse relationship between levels of fertility and secondary metabolite production. Early results also confirmed that as fertility decreased, root mass per unit of above ground biomass increased. In addition, we found significant adjustments in Canopy Area Index (CAI) and Leaf Area Index (LAI) were required during August and September to account for the ET estimates of fast growth rate of willow. Measurements included potting media moisture content as monitored with tensiometers, water delivered per plant and nutrients (NPK) delivered per plant.

Moisture Tension Control of Microirrigation for Potted Mini-Roses *R.C. Hansen*

Four precision load cells (+/- 5 g) were used with a data gathering system (Campbell 21X) during 1998-99 to simultaneously measure evapotranspiration (ET) of four mini-rose plants and to correlate ET with moisture tension as measured with tensiometers. The Campbell 21X system recorded weight, ambient temperature, relative humidity and solar radiation while the Q-COM software recorded tension readings. The effects of tensiometer location within a container are being studied. Various levels of tension used to start and stop irrigation are being tested. Measured ET for mini-roses is being compared to calculated ET using Stanghellini and Fynn ET models.

Recent Publications

Fleisher, D.H. (Advisor: Ting, K.C.) 2001. *Crop modeling for multiple crop production and control for advanced life support systems*. Ph.D. Dissertation, Rutgers University.

Hsiang, H. (Advisor: Ting, K.C.) 2001. *Top-level modeling of a food processing and nutrition (FPN) component of an advanced life support system (ALSS).* M.S. Thesis, Rutgers University.

Lee, In-Bok, T.H. Short, S. Sase, and S. Lee. 2001. Evaluation of computational fluid dynamics for analysis of aerodynamics in naturally ventilated multi-span greenhouses. *Journal of Agricultural and Biosystems Engineering, Korea* 1(2): 73-80.

Lee, In-Bok and T.H. Short. 2001. Verification of computational fluid dynamic temperature simulations in a full-scale naturally ventilated greenhouse. *Transactions of the ASAE* 44(1): 119-127.

Kacira, M. and P.P. Ling. 2001. Design and development of an automated and non-contact sensing system for continuous monitoring of plant health and growth. *Transactions of the ASAE* 44(4): 989-996.

Kirnak, H. and T.H. Short. 2001. An evapotranspiration model for nursery plants grown in a lysimeter under field conditions. *Turkish Journal for Agriculture and Forestry* 25(1): 57-63.

Kim, Y. and P.P. Ling. 2001. Machine visions guided sensor positioning system for leaf temperature assessment. *Transactions of the ASAE* 44(6): 1941–1947.

Prenger J. and P. Ling. 2001. Greenhouse condensation control – understanding and using vapor pressure deficit (VPD)**.** *Ohio State University Extension Fact Sheet, AEX-804-2001*. The Ohio State University, Columbus, OH 43210.

Short, T.H. 2001. How to control energy costs. *Greenhouse Management & Production (GMPRO) Magazine* 21(4): Feature article for April issue.

Symposium Proceedings/Presentations (2001)

Fleisher, D.H., H. Baruh and K.C. Ting. 2001. Model-based predictive control for biomass production in advanced life support. *Proceedings of the 2nd IFAC-CIGR Workshop on Intelligent Control for Agricultural Applications*. Bali, Indonesia. August 22-24. pp. 198-203.

Short, T.H., In-Bok Lee and R.R. Stowell. 2001. Naturally-ventilated greenhouse designs for optimum cooling. *Proceedings of ISHS Symposium on Protected Cultivation in Mild Winter Climates*. ISHS, Cartagena, Spain, March 7-11. Acta Horticulturae No.( ) (Accepted for publication).

Short, T.H. and In-Bok Lee. 2001. Temperature and airflow predictions for multi-span naturally ventilated greenhouses. *Proceedings of International Symposium on Design and Environmental Control of Tropical and Subtropical Greenhouses*. ISHS, Taichung, Taiwan, April 15-18. p.18.

Short, T.H. 2001. An interactive decision model for hydroponic tomato production. *Proceedings of International Symposium on Design and Environmental Control of Tropical and Subtropical Greenhouses*. ISHS, Taichung, Taiwan, April 15-18. p.35.

Ting, K.C. 2001. Concurrent science and engineering approach to decision support for controlled environment plant production. *Proceedings of International Symposium on Design and Environmental Control of Tropical and Subtropical Greenhouses*. ISHS, Taichung, Taiwan, April 15-18. pp. 85-94.

Internet Sites

http://www2.oardc.ohio-state.edu/hydroponics/Home/default.htm

This is a web site of the hydroponic tomato interactive program.