NCR 101 Station Report
The Ohio State University

Equipment/ Sensors / Control Systems:
A spectrometer system was recently acquired for spectroscopic studies of plants. The ASD Field Spec FR Jr system has a spectral sensitivity between 350 to 2500 nm and is suitable for bench top as well as field spectral data collection. The system also includes an external integrating sphere for reflectance and transmittance measurements.

The Ohio State researchers are continuing their effort in developing early, non-contact sensing technologies for plant stress detection. The focus is on using spectral information between 400-2500 nm (VIS, NIR, and MIR) and 8-12 μm (infrared thermometry), and plant movement information for early water stress detection. Using New Guinea Impatiens as a model plant, it was found possible to detect the water stress one day before human identification of the stress using plant canopy temperature based crop water stress index (CWSI). A robotic sensor delivery system was also developed for precise placement of an infrared temperature sensor for accurate, non-contact plant canopy temperature measurement. On going effort is devoted to develop methodologies using spectral information in VIS, NIR, and MIR ranges for the water stress detection.

Unique Plant Responses:
New Guinea Impatiens's pant canopy movement was found to be a good indicator of the plants' water status. Using machine vision measured top projected canopy area (TPCA), good correlation was established between the plants' transpiration rate and the plant's movement that defined by the TPCA change as a function of time. Drought stress induced plant movement was de-coupled from total TPCA changes due to a combination of diurnal movement, drought stress affected movement, and plant growth.

Committees / Panels:
ASAE Environment of Plant Structures Committee (Ling)
ASAE Nursery and Greenhouse system Engineering Committee (Hansen, Ling, Short)

Research:
Continued to study moisture tension control of micro-irrigation for potted mini-roses. Four precision load cells (+/- 5 g) mounted on an aluminum A-frame with an associated data gathering system (Campbell 21X) were used to simultaneously measure transpiration of four mini-rose plants and to correlate transpiration with moisture tension as measured with tensiometers.

Continued to develop feed-forward computer control algorithms to irrigate Acer Rubrum (Red Maple) trees in proportion to predicted transpiration. Transpiration rates of Acer Rubrum and related climate variables were measured continuously in a very high evaporative demand greenhouse environment and compared independently to solar radiation and vapor pressure deficit (VPD). Measured transpiration rates were further compared to predicted transpiration based on the combination equation. Based on regression analyses and the coefficient of determination (R^2), the single variable VPD predicted transpiration equally well as the combination model with an R^2 value for both equal to 0.861. Meanwhile, using the single variable solar radiation to predict transpiration resulted in an R^2 value of 0.652.

Continued effort in developing technology for closed-loop plant production systems. Advanced sensing technology as well as evapotranspiration models are being developed for controlled environment plant production. The focus was to develop closed-loop feedback and feed-forward control systems for water management in controlled environment. Using infrared thermometry and machine vision technology, it was possible to detect drought stress of New Guinea Impatiens one day before human observation of the stress symptom.

Selected Publications:

1. Al-Arifi A., T. Short, and P.P. Ling. 1999. Influence of shading ratio, air velocity, and evaportranspiration on greenhouse crop microclimate. International ASAE Meeting, Toronto, Canada. ASAE Technical Paper No. 994228.
2. Cavazzoni, J. and P.P. Ling. 1999. Using machine vision and crop models for closed-loop plant production in advanced life support systems. *International Journal of Life Support & Biosphere Sciences*. (accepted for publication)
3. Hansen, R.C. and C.C. Pasian. 1999. Using tensiometers for precision microirrigation of container-grown roses. *Applied Engineering in Agriculture* 15(5): 483-490.
4. Kacira, M., P.P. Ling, T.H. Short. 1999. A Review on Non-Contact Sensing of Plant Water Stress Using Infra-Red Thermometry for Controlled Environment Plant Production. 7th International Congress on Agricultural Mechanization and Energy. May 26-27, 1999, Adana, Turkey. pp. 383-388.
5. Kacira, M., P.P. Ling, and T. Short. 1999. Non-contact sensing of plant water stress by IR thermometry and image processing. International ASAE Meeting, Toronto, Canada. ASAE Technical Paper No. 995004.
6. Kacira, M., T.H. Short, R.R. Stowell. 1999. Computational Fluid Dynamics as a Tool for Analysis of Natural Ventilation of a Sawtooth Greenhouse. 7th International Congress on Agricultural Mechanisation and Energy. May 26-27. Adana, Turkey. pp. 277-282.
7. Kacira, M. 2000. Non-contact and early detection of plant water stress using infrared thermometry and image processing. Ph.D. dissertation.
8. Kim, Y., P.P. Ling, K.C. Ting, and N. Kondo. 1999. Development of a robotic camera system for 3-D sensor positioning. International ASAE Meeting, Toronto, Canada. ASAE Technical Paper No. 993075.
9. Kim, Yunseop. 1999. Machine vision guided sensor delivery system for plant temperature measurement. Master thesis.
10. Lee, I. and T.H. Short. 1999. Analysis of the Efficiency of Natural Ventilation in a Multi-Span Greenhouse Using CFD Simulation [In Japanese]. Journal of Bio-Environment Control. 8(1):9-18.
11. Lee, I. and T.H. Short. 1999. Fluid Dynamic Simulation of a Naturally Ventilated Multi-span Greenhouse. (Korea - in review)
12. Lee, I. and T.H. Short. 1999. Two Dimensional Numerical Simulation of Natural Ventilation in a Multi-span Greenhouse. Transactions of the ASAE (in review).
13. Lee, I. and T.H. Short. 1999. Computational Fluid Dynamic Study for Structural design of Naturally Ventilated Multi-Span Greenhouses. ASAE Paper 995010.
14. Lee, I., P. Fynn, and T.H. Short. 1999. Performance Evaluation of a Computerized Fertigation System. Applied Engineering in Agriculture (in review).
15. Short, T. 1999. Building a Better Greenhouse--A New Era for Natural Ventilation. Proceedings for the 15th Conference on Insect and Disease Management on Ornamentals, Feb. 20-22, 1999. Fort Lauderdale, FL. pp. 5-12.
16. Short, T.H., A. Irvim and R.C. Hansen. 1999. Transpiration of container-grown *Acer Rubrum* under conditions of high evaporative demand. *Applied Engineering in Agriculture* 15(5): 553-557.
17. Short, T.H., A. El-Attal, H.M. Keener. 1999. A decision model for hydroponic greenhouse tomato production. Proceedings of ISHS Symposium on Models for Plant Growth. Antalya, Turkey. (In Press)

Workshops:

i) Greenhouse Engineering Workshop - Automated Water Management. 3/11/99-3/12/99. Wooster, OH. Approximately 50 attendees.
ii) Greenhouse Engineering Workshop - Pesticide Application. 2/29/00-3/1/00. Wooster, OH. Approximately 80 attendees.

Website:
A home page is available for Peter Ling's research activities: http://www.oardc.ohio-state.edu/ling/index.html