NCERA-101

Committee on Controlled Environment Technology and Use

2007-2008 Annual Station Report

State of Ohio, USA

Peter Ling and Robert Hansen
Department of Food, Agricultural and Biological Engineering
The Ohio State University
Contact: ling.23@osu.edu

Jonathan Frantz, James Locke, Charles Krause
USDA-ARS, Greenhouse Production Research Group, Toledo, OH
Contact: jonathan.frantz@ars.usda.gov

New facilities planned or installed

The USDA-ARS, Greenhouse Production Research Group (USDA-ARS GPRG) installed the following facilities: The large, walk-in chamber from EGC was retrofitted with six smaller Plexiglas chambers similar to the ones in Utah State and U of Georgia. These chambers are constantly cooled with a copper heat exchanger with recirculating chilled water, and the chambers have three 45-W resistance heaters that are activated when the temperature drops below a set point. All control is performed with a CR10X datalogger and a SDM-CD16AC controller.

New/different control systems

A prototype precision nutrient delivery system designed for high turn-down ratio nutrient delivery to multiple, small sizes plots was evaluated and found its performance satisfactory in a laboratory setting. The system will be further evaluated for field applications.

Sensors and instruments

USDA-ARS GPRG continues to develop Virtual Grower software, a decision support tool for greenhouse growers. Virtual Grower 2.0 was released officially on Feb 26th, 2008. This version has plant growth and development predictions for seven floricultural crops and one vegetable crop, as well as additional detail on shade curtain options, heating efficiency descriptions, and a method of estimating air infiltration through gaps. More than 3,000 copies have been distributed.

USDA-ARS GPRG and OSU Extension developed a sensor package using the NCR-101 sensor package as a model, to be used by greenhouse growers in the NW Ohio area. Its use has enabled growers to determine low CO_2 in the winter time when structures are sealed tightly, light and temperature uniformity, and potential ways to save energy. This

package will enable greenhouse growers to spot check their environment with common instruments and enable better communication between researchers, extension agents, and stakeholders.

OSU is developing a precision whole plant photosynthesis measurement system. One of the research objectives is to establish minimum sensor sensitivity requirements for the CO_2 dynamics monitoring.

Unique plant responses

USDA-ARS GPRG has tested another 15 floriculture species for their ability to take up and accumulate Si. Silicon-amended hydroponic solutions can enable zinnia to withstand Cu toxicity stress by activating general stress response pathways and limiting Cu transport into the leaves.

When geranium plants are exposed to boron-deficient conditions, the stress is mititgate somewhat by increased light. Compared to plants grown in a daily light integral of 5.76 mol m^{-2} d^{-1}, plants grown in 17.3 mol m^{-2} d^{-1} had delayed visible B deficiency symptoms and did not decrease photosynthetic rates until 4 days after the initial symptoms appeared in the low-light-grown plants and 5 days after initial B deficiency stress began.

Accomplishment Summaries

Ohio reviewed construction and operation of open type whole canopy photosynthesis measurement systems and published a paper highlighting key parameters affecting the photosynthesis measurement accuracy (Takahashi et al., 2008).

OSU developed an improved GFP expression quantification system for promoter analysis of transgenic plant tissues. Green fluorescent protein (GFP) expression is used to evaluate genetic transformation and gene expression. GFP expression quantification in plant tissues, however, is often complicated by the presence of chlorophylls. A systematic approach was used to improve the GFP quantification. Three major aspects of this effort were: (1) development of an innovative approach of using the herbicide isoxaflutole (IFT) to eliminate chlorophylls and to enhance the GFP expression quantification, (2) evaluation of a multispectral feature selection approach to extract GFP detection and block other autofluorescence, and (3) evaluation of image processing adaptive thresholding techniques for the improvement of GFP expression quantification (Wu et al., 2008).

Impact Statements

The review of whole canopy photosynthesis measurement conducted by Ohio has provided a reminder of necessary steps to assure photosynthesis measurement accuracy using open type whole canopy photosynthesis measurement systems. A manuscript on the topic has been accepted for publication in a refereed journal. This contribution to the

literature should help to promote more reliable photosynthesis measurements using the most popular whole canopy photosynthesis system such as the open type.

The GFP quantification methodologies developed by The Ohio State University will help to improve accuracy and reliability of analyzing GFP (green fluorescent protein) expression as a tool to understand factors affecting performance of gene formation processes. The ability to decouple autofluorescent signals from plant pigments will allow more precise identification of the fluorescent signal generated from GFP.

With a computer-controlled fertigation system, water, chemicals and nutrients can be delivered as prescribed, rather than being restricted to a pre-determined weekly irrigation schedule or the unpredictability of slow-release fertilizers. Optimum plant growth and health can be achieved by conserving water, nutrients and/or pesticides thus limiting runoff while avoiding plant stress due to deficient applications.

Published Written Works

- Chiera, J. M., Bouchard, R. A., Dorsey, S. L., Park, E., Buenrostro-Nava, M. T., Ling, P. P., and Finer, J. J. 2007. Isolation of two highly active soybean (Glycine max (L.) Merr.) promoters and their characterization using a new automated image collection and analysis system. Plant Cell Reports 26:1501-1509.
- Frantz, J.M., J.C. Locke, L. Datnoff, M. Omer, A. Widrig, D. Sturtz, L. Horst, C.R. Krause. Detection, distribution, and quantification of silicon in floricultural crops utilizing three distinct analytical methods. Comm. Soil Sci. Plant Analysis. *Accepted 8-31-07*
- Frantz, J., J. Locke, D. Pitchay. 2007. Improving Growth of Calibrachoa in Hanging Flower Pouches. HortTechnology 17:199-204.
- Frantz, J.M., N.N. Cometti, M.W. van Iersel, B. Bugbee. 2007. Rethinking acclimation of growth and maintenance respiration of tomato in elevated CO_2: effects of a sudden change in light at different temperatures. J. Plant Ecol. 31:695-710.
- Omer, M., J.C. Locke, J.M. Frantz. 2007. Using leaf temperature as a nondestructive procedure to detect root rot stress in geranium. HortTechnology 17:532-536.
- Rofkar, J., D. Dwyer, and J. Frantz. 2007. Arsenic Accumulation by Plant Species Selected for Growth in Northwest Ohio. Comm. Soil Sci. Plant Analysis. 38:2505-2517.
- Takahashi, N., Isogai, A., Ling, P. P., Kato, Y., and Kurata., K. 2007. Effects of Elevated Atmospheric Carbon Dioxide Concentration on Silica Deposition in Rice (Oryza sativa L.) Panicle. Plant Production Science vol (11). Accepted for publication.
- Takahashi, N., Ling, P. P., and Frantz, J. M. 2007. Considerations for Accurate Whole Plant Photosynthesis Measurement. Environmental Control in Biology. Accepted for publication.
- Wu, C., Chiera, J. M., Ling, P. P., and Finer, J. J. 2007. Wu, C., J.M. Chiera, P.P. Ling, and J.J. Finer. 2007. Isoxaflutole treatment leads to reversible tissue bleaching and allows for more effective detection of GFP in transgenic soybean tissues. In Vitro Cellular and Development Biology – Plant. Accepted for publication.

Scientific and Outreach Oral Presentations

- Takahashi, Noriko, Peter P. Ling, Michael Klingman, and Jonathan M. Frantz. 2007. System Approach for Improved Whole Canopy Photosynthesis Measurement. Japanese Society of Agricultural, Biological, and Environmental Engineers and Scientists 2007 conference, June 25-27, Sakai, Osaka, Japan. Paper number: B31-6, pp184-185. Peer Reviewed.
- Ling, P. P., N. Takahashi, and J. Frantz. 2007. Considerations for Accurate Whole Plant Photosynthesis Measurement, ASABE Annual International Meeting, Minneapolis, Minnesota, 17 - 20 June 2007. ASABE Paper No. 074015.

i. Unpublished scholarly presentations

- Ling, P. P., and N. Takahashi. 2007. Considerations of whole canopy photosynthesis measurement. 4/16/2007. NCR-101 Meeting, Tuskegee, AL.
- Ling, P. P. 2007. An overview of plant sensing and control program. Wageningen, Netherlands. 8/30/2007.
- Wu, C., J.M. Chiera, P.P. Ling and J.J. Finer. 2007. Isoxaflutole treatment leads to reversible tissue bleaching and allows for more effective detection of GFP in transgenic soybean tissues. NABEC Conference, Wooster, OH.
- Takahashi, N. and P. P. Ling. 2007. Improvement of whole plant photosynthesis measurement. NABEC meeting. 7/30/2007.
- Ling, P. P. 2007. Greenhouse Production Efficiency: elevate the end user, elevate the use. National Greenhouse Manufacturer Association. Palm Beach, FL. 4/23-24/07.

Cooperative/Interdisciplinary Projects

- Biomonitoring of nutritional status of bedding plants; John Gray and Scott Heckathorn, University of Toledo, Jonathan Frantz, USDA/ARS, began April, 2004.
- Determining the factors controlling sudden pH decline in geranium production; Paul Nelson, North Carolina State University, Jonathan Frantz, USDA/ARS, began May 2004.
- The use of silicon as a beneficial nutrient in bedding plant production; Lawrence Datnoff, University of Florida, James Locke, USDA/ARS, began March 2005.
- Nutrient uptake and partitioning in petunia as influenced by environment; Peter Ling, The Ohio State University, Jonathan Frantz, USDA/ARS, began March 2005.
- Determining the fate of agrochemicals in the greenhouse; Alison Spongberg, University of Toledo and Jonathan Frantz, USDA/ARS, began May 2005.
- Susceptibility of floricultural crops to viral pathogens as a function of plant nutrition; Scott Leisner, University of Toledo, James Locke, USDA/ARS, began August 2005.
- Economic evaluation and technical support of new hydroponic vegetable growers using HID supplemental lighting via personal visits and interactive web-site tools at http://www.oardc.ohio-state.edu/hydroponics/, Ohio State University Research & Extension, Ted Short and Mary Donnell.
- Development of a State-of-the-Art Computer-Controlled Nutrient Delivery System for Container-Grown Landscape Nursery Crop Research; Dan Herms of Entomology

Department, OSU, Robert Hansen of Food, Agricultural and Biological Engineering Department, and Alec Mackenzie, Argus Control Systems LTD.

- Development of a State-of-the-Art Computer-Controlled Nutrient Delivery System for Container-Grown Landscape Nursery Crop Research; Dan Herms of Entomology Department, OSU, Robert Hansen of Food, Agricultural and Biological Engineering Department, and Alec Mackenzie, Argus Control Systems LTD.

Workshops/Colloquia/Symposia

- Ling, P.P. Organizer. Greenhouse Management Workshop. 2/6-7/2007. Wooster, OH.
- Ling, P.P. and Christine Coker. Greenhouse Automation Sessions. GrowerTalks' Greenhouse Experience & Pest Management Conference. Cleveland, OH. Sept 11, 2007.

Committees and Sub-committees Served

- Ling, P.P. Associate Editor. HortTechnology
- Frantz, J.M. Chair of Controlled Environment Working Group, ASHS
- Hansen, R.C. Chair: SE-406 Nursery & Greenhouse Systems Committee, ASABE

Internet sites of interest

- Hydroponics: http://www.oardc.ohio-state.edu/hydroponics/
- Virtual Grower: http://www.ars.usda.gov/Research/docs.htm?docid=11449