

NCERA-101
Committee on Controlled Environment Technology and Use
2009 Annual Station Report

State of Ohio, USA

USDA-ARS, Toledo, OH, Jonathan Frantz, Jim Locke, Medani Omer, Bryon Hand, Doug Sturtz, Alycia Pittenger

OSU, Wooster, OH, Peter Ling, Robert Hansen, Noriko Takahashi

1. Impact Nugget: The Ohio State University team developed and characterized a rapid, whole-plant gas exchange system to improve measurement efficiency by reducing setup time between experimental set points, and to detect transient photosynthesis response due to short term environmental stimuli. The USDA-ARS team in Toledo, OH released Virtual Grower 2.0 software, and over 1,700 copies have been distributed since its release.

2. New Facilities and Equipment. A temperature control system was installed in the 6-chamber controlled environment facility, modeled after the 10-chamber facility in Utah State University. An ICP-Mass Spec purchased by a collaborator and installed in the ARS facility

3. Unique Plant Responses. Elevated CO₂ (to 500 ppm) compensated for a three degree (F) decrease in temperature in stock geranium and lettuce production in a commercial greenhouse facility in Toledo, OH. Elevated light (17.2 mol m⁻² d⁻¹) delayed initial stress symptoms of boron deficiency in geranium compared to lower light (5.76 mol m⁻² d⁻¹), likely due to increased B mobility from carbohydrate re-distribution. Eventually, higher light-grown plants had more severe deficiency symptoms. Silicon alleviated copper toxicity stress in hydroponically grown *Arabidopsis* plants, in part by active regulation of proteins involved in metal uptake and distribution.

4. Accomplishment Summaries. Virtual Grower software was developed to allow a user to easily build, in software, a greenhouse that closely matched their facility so that energy simulations could be run conveniently. Virtual Grower 2.0 was released in 2008, which had plant growth simulation capabilities, as well as improved user interface, additional energy curtain options, and more descriptions of air infiltration (leakage) and heating system efficiency. These changes allow a user to see the impact that optimizing in one area (heating efficiency) may have on plant growth and scheduling. The software has enabled growers and engineers to more easily obtain energy audit information with which owners can seek funding for energy efficiency improvements. Over 1,700 copies of VG 2.0 have been distributed, primarily through the website www.virtualgrower.net.

In a walk-through of a commercial facility in 2007, it was noticed that CO₂ concentrations were low (~200 ppm), especially in well-sealed houses designed for low air infiltration (leakage). We established a CO₂ control system for one house and allowed CO₂ to be uncontrolled in an identical house at this commercial facility. By controlling CO₂ to 500 ppm, the grower could reduce temperature by 3 F and save 10% of his typical energy use. The system paid for itself in 1 season, resulted in higher yield and quality of geranium stock plants and lettuce, and lowered the carbon footprint of his production by 60%.

A rapid whole canopy photosynthesis measurement system has been developed to address the concerns and limitations of currently available CO₂ gas exchange chambers. The improved system has better response time, but similar accuracy and reliability of determining whole plant CO₂ exchange compared to the systems of colleagues at Utah State Univ. and Univ. of Georgia.

A review article was published summarizing factors affecting photosynthesis measurement accuracy using open type whole canopy photosynthesis measurement systems. The documentation can be used as a quality control tool to improve photosynthesis measurements.

5. Impact Statements. Virtual Grower software continues to be developed by the USDA-ARS team in Toledo, OH. The software allows a user to design greenhouses and simulate heating and plant growth for 12 greenhouse

crop species. Users can optimize management strategies to save energy and improve scheduling. Over 5,000 copies have been distributed, with typical, easy-to-implement savings of around 20%.

The rapid whole canopy photosynthesis system developed at OSU can be used to improve measurement efficiency by reducing setup time between experimental set points, and to detect transient photosynthesis response due to short term environmental stimuli.

6. Published Written Works.

Refereed Journal Articles

- Brantner J. R., Windels, C. E., and Omer M. 2008. Verticillium wilt on sugar beet following potatoes in eastern North Dakota. Plant Health Progress doi:10.1094/PHP-2008-1212-01-BROnline
- Frantz, J.M., J.C. Locke, L. Datnoff, M. Omer, A. Widrig, D. Sturtz, L. Horst, C.R. Krause. 2008. Detection, distribution, and quantification of silicon in floricultural crops utilizing three distinct analytical methods. Comm. Soil Sci. Plant Analysis. 39:2734-2751.
- Li, J., S. Leisner, J.M. Frantz. 2008. Alleviation of copper toxicity in *Arabidopsis thaliana* by silicon addition to hydroponic solutions. J. Amer. Soc. Hort Sci. 133:670-677.
- Mishra, S., S. A. Heckathorn, D. Barua, D. Wang, P. Joshi, E. W. Hamilton, J. Frantz. 2008. Interactive effects of elevated CO₂ and ozone on leaf thermotolerance in field-grown Glycine max. J. Integ. Plant Biol. 50:1396-1405.
- Okayama, T., Yang, Y., Ling, P. P., and Murase, H. 2008. Estimation of evapotranspiration rate using neural network with plant motion. Environmental Control in Biology 46(1):13-19.
- Omer, M., Johnson, D.H, Douhan, L.I., Hamm, P.B, and Rowe, R.C 2008. Detection, quantification, and vegetative compatibility of *Verticillium dahliae* in potato and mint production soils in the Columbia Basin of Oregon and Washington. Plant Dis. 92:1127-1131.
- Takahashi, N., Isogai, A., Ling, P. P., Kato, Y., and Kurata., K. 2008. Effects of Elevated Atmospheric Carbon Dioxide Concentration on Silica Deposition in Rice (*Oryza sativa* L.) Panicle. Plant Production Science 11 (3): 307-315.
- Takahashi, N., P.P. Ling, J.M. Frantz. 2008. Consideration for accurate whole plant photosynthesis measurement. Environ. Control Biol. 46:71-81.
- Taylor, M., P. Nelson, and J.M. Frantz. 2008. Substrate Acidification by Geranium (*Pelargonium x hortorum*): Temperature Effects. J. Amer Soc. Hort Sci. 133:508-514.
- Taylor, M., P. Nelson, and J.M. Frantz. 2008. Substrate Acidification by Geranium (*Pelargonium x hortorum*): Light Effects and Phosphorus Uptake. J. Amer Soc. Hort Sci. 133:515-520.
- Wu, C., Chiera, J. M., Ling, P. P., and Finer, J. J. 2008. 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.6:540-547.
- Yang, Y., Ling, P. P., Fleisher, D. H., Timlin, D. J., and Reddy, V. R. 2008. Non-contacting Techniques for Plant Drought Stress Detection. Transactions of the ASABE 51(4): 1483-1492.

Trade Magazine Articles

- Blanchard, M., E. Runkle, and J. Frantz. 2008. Responses to temperature and light. Greenhouse Grower. 26:1-7.
- Ling, P. P. 2008. Cutting a Greenhouse Heating Bill. Ohio Country Journal. February.

Poster Presentations

- Jeong, K.Y., B. Whipker, I. McCall, and J. Frantz. 2008. Gerbera leaf tissue nutrient sufficiency ranges by chronological age. International Symposium on Soilless Culture and Hydroponics, Lima, Peru.
- Jeong, K.Y., B. Whipker, I. McCall, C. Gunter, and J. Frantz. 2008. Characterization of nutrient disorders of gerbera hybrid "Festival Yellow with Light Eye". International Symposium on Soilless Culture and Hydroponics, Lima, Peru.
- Mishra, S., S. Heckathorn, J. Frantz, F. Yu, and J. Gray. 2008. Modest increases in growth light level protect photosynthesis and plant growth during boron stress in geraniums. HortScience 43:1278.
- Omer, M., Frantz, J. M., Locke, J. C. 2008. The influence of phosphorus concentration on the development of Pythium root rot disease of seedling geranium. Phytopathology: 98

Pasian, C. and J. Frantz. 2008. Evaluating fibrous polyethylene terephthalate and cellulose as components for soilless substrates. American Society for Horticultural Science Annual Meeting, Orlando, FL. HortScience 43:1182.

7. Scientific and Outreach Oral Presentations

- Fausey, B. A., Draper, C. M., Hansen, R. C., Keener, H. M., and Ling, P. P. 2008. Research and Outreach Efforts Sustain the Ohio Hydroponics Industry.
- Frantz, J. 2008. Controlled release fertilizer use and challenges in containerized production, Toledo, OH (host and organizer).
- Frantz, J. 2008. Floriculture research at the USDA-ARS: growing flowers in a pork barrel. Texas A&M Horticulture Department Seminar Series, College Station, TX.
- Frantz, J. 2008. Observations on greenhouse management during Virtual Grower 2.0 development. Toledo Area Flower and Vegetable Growers Association Bedding Plant Clinic, Toledo, OH.
- Frantz, J. 2008. Energy efficiency in greenhouse production: heating and heating alternatives. American Society for Horticultural Science Annual Meeting, Orlando, FL.
- Frantz, J. 2008. Saving energy with a self-evaluation: how Virtual Grower can help you. Indiana Flower Growers Annual Conference, West Lafayette, IN.
- Frantz, J. and C. Pasian. 2008. Evaluating performance and stability of polyethylene terephthalate (PET) and cellulose polymer as soilless mix components. International Symposium on Soilless Culture and Hydroponics, Lima, Peru.
- Frantz, J. and E. Fritz. 2008. Greenhouse simulators: useful software for greenhouse management. OFA Short Course, Columbus, OH.
- Frantz, J.M. 2008. Optimizing lettuce production. Greenhouse Engineering Workshop, Wooster, OH.
- Frantz, J.M. and B. Fausey. 2008. Instrument package for grower use in Ohio. Greenhouse Engineering Workshop, Wooster, OH.
- Frantz, J.M. and B. Hand. 2008. Virtual Grower and other useful, free software for greenhouse management. Greenhouse Engineering Workshop, Wooster, OH.
- Li, J., J. Frantz, and S. Leisner. 2008. Alleviation of copper toxicity in Arabidopsis thaliana and Zinnia elegans by silicon addition. Silicon in Agriculture Conference, Durban, South Africa.
- Ling, P.P. 2008. Horticultural Engineering Research at OSU. Wooster, OH
- Ling, P.P. 2008. An overview of plant sensing and control research program. Columbus, OH.
- Ling, P.P. 2008. Energy Efficient Plant Production. West Lafayette, IN
- Ling, P.P. 2008. Greenhouse research and extension programs at OSU. Wooster, OH.
- Ling, P.P. 2008. Energy Efficient Environmental Control and Alternative Energy for Greenhouse Plant Production. American Society for Horticultural Science Annual Meeting, Orlando, FL.
- Ling, P.P., 2008. Considerations for Greenhouse Productivity Improvement. Tri-State Green Expo. Cincinnati, OH.
- Ling, P.P., 2008. Extension Reloaded - 2008 Cleveland East. Cleveland, OH
- Ling, P.P., 2008. "Energy strategy for the future: a 30,000 ft overview to find low cost energy. OFA Short Course, Columbus, OH.
- Locke, J. and J. Frantz. 2008. Evaluating silicon uptake in floriculture crops grown in the US. Silicon in Agriculture Conference, Durban, South Africa.
- Takahashi, N., Ling, P. P., Frantz, J., and Klingman, M. 2008. Time response improvement of a whole canopy photosynthesis measurement system. ASABE Annual International Meeting, Providence, RI, June 29 - July 2, 2008. ASABE Paper No. 085141.
- Taylor, M., J. Frantz, and P. Nelson. 2008. High light suppression of phosphorus uptake and consequent root substrate acidification by geranium. American Society for Horticultural Science Annual Meeting, Orlando, FL.
- Whipker, B., J. Gibson, P. Nelson, and J. Frantz. 2008. Nutritional diagnostics LIVE! OFA Short Course, Columbus, OH.

8. Other relevant accomplishments and activities. None