THE UNIVERSITY OF
ARIZONA

REPORT FOR THE NCERA-101 MEETING 2012

Chieri KUBOTA Murat KACIRA
ckubota@ag.arizona.edu mkacira@cals.arizona.edu

1. Impact Nuggets

- Kacira Lab developed multicamera based computer vision guided crop sensing and monitoring system for crop diagnostics. The monitoring system uses a color, NIR and thermal camera to acquire and process canopy images ultimately providing both greenhouse aerial and canopy based information in a web based decision support platform to help grower for improved production management. The system is currently being evaluated with experiments.

- Kacira Lab developed a complete computational fluid dynamics model including turbulence model for air flow, porous media model for canopy existence, evapotranspiration model for canopy-greenhouse mass and energy exchange, phase change model for high pressure fogging to evaluate climate uniformity for naturally vented greenhouse equipped with high pressure fogging. The model can be used for providing recommendations for various installations and operational characteristics of high pressure fogging systems in greenhouse for cooling.

2. New Facilities and Equipment

- Dr. Kubota acquired Orbitec LED bars with red and blue light emissions (Orbitec, Madison, WI) for her study on supplemental LED lighting for horticultural crops (USDA SCRI project with Purdue, Michigan State, and Rutgers Universities).
- Dr. Kubota had a 1000 sq ft greenhouse re-glazed with 'F-Clean' ETFE film (diffuse, UV transmitting; AGC Green Tech, Tokyo, Japan) for testing plant responses under the film.
- Dr. Kubota acquired new sensors: a Vaisala GM70 hand-held CO_2 meter, a Kipp & Zonen CGR 3 Pyrgeometer (for longwave radiation measurement), and Licor LI-191 line quantum sensor
- Kacira Lab built two high tunnel greenhouses, one is grid connected and the other is off-the-grid powered by photovoltaics (PV) system. The greenhouses are fully instrumented to account for all resource inputs for crop production as well as crop yield and PV system energy outputs. The research aims to evaluate technoeconomical feasibility of this off-the-grid greenhouse for sustainable food production in remote or challenged sites where immediate access to resources (i.e. water, chemical fertilizer, power) is limited.

3. Unique Plant Responses.

- Ricardo Hernandez (PhD student) and Dr. Kubota examined young seedlings of four vegetable plant species under supplemental LED lighting with varied blue/red ratios. Growth parameters such as dry and fresh shoot mass and morphological parameters such as number of leaves, stem diameter, hypocotyl length, and chlorophyll concentration showed that the supplemental lighting improved the growth and transplant quality of cucumber seedlings, compared with the control. However, increase of blue/red ratio decreased plant growth (leaf area and dry mass), especially under lower DLI.
- Dr. Kubota and Mark Kroggel found that night time VPD control (to <0.1 kPa) is essential to reduce the incidence of tip burn and calyx burn of strawberry plants grown under relatively high VPD in semi-arid greenhouse. In their 2010 experiment using two cultivars, the night time high humidity treatment exhibited significantly lower percent calyx burn (16.7%) and tip burn (9.0%) than non-treated control (48.6% and 47.2%, respectively) throughout the experiment. When uncovered, cultivar 'Camino Real' had more tip/calyx burn (58.9%) than 'Albion' (37.0%). The nighttime average VPD was 0.09 kPa under the floating cover and 0.88 kPa in air inside the greenhouse. No particular difference was observed for disease, as foliage was completely dry during the day (average VPD: 1.6 kPa) For 2011 experiment, a simple curtain system was developed for nighttime VPD treatment. For a larger scale operation, automated curtain may be a possibility as a low cost solution of tip/calyx burns for strawberry grown in semiarid greenhouses.
-

4. Accomplishment Summaries

- As part of UA Plant Sciences team, Dr. Kubota organized a Controlled Environment Biology and Technology showcase inspired 4th-8th graders at the FunFest (February 16-17, 2012; Tucson, AZ), presenting mini hydroponic systems and the biology and physics behind plant lighting (LEDs), plant sensing and vegetable grafting. The festival engaged over 300 professional scientists and experts who provided interactive displays and short

workshops that introduce 4th- 8th graders to principles of math, science and engineering in a fun and memorable way. More than 6,000 students and science teachers from Southern Arizona attended the event.

- University of Arizona Controlled Environment Agriculture Center (UA CEAC) organized the 12th Greenhouse Crop Production and Engineering Design Short Course (April 9-13, 2012) with ~100 participants. CEAC organized hands-on workshops during the short course. One of the five hands-on workshops offered was 'greenhouse sensors and instrumentation basics' in which Dr. Murat Kacira introduced the theory, practical use and calibration of sensors and control systems used in greenhouse crop production.
- Dr. Kubota developed an online professional course of Greenhouse Plant Physiology to meet the educational need for growers and farm managers working in horticultural industries to learn whole plant physiology (plant responses) under controlled environment. A pilot course is launched to serve for 50 students in California in the fall 2012.
- University of Arizona Controlled Environment Agriculture Center (UA CEAC) took an active role for organizing 1st CFD symposium under 2012 CIGR-EuroAgEng conference on July 7-11 held in Valencia, Spain. The symposium brought together diverse group of CFD experts to address various challenges on aerodynamics analysis of CEA, food processing, precision farming systems.

5. Impact Statements

N/A

6. Published Written Works

(1) Peer review journal papers

Bartzanas, T., M. Kacira, H. Zhu, S. Karmakar, E. Tamimi, N. Katsoulas, I. Lee, C. Kittas. 2012. Computational fluid dynamics applications to improve crop production systems. Computers and Electronics in Agriculture. (In Press)

Boscheri, G., M. Kacira, L. Patterson, G. Giacomelli, P. Sadler, R. Furfaro, C. Lobascio, M. Lamantea, L. Grizzaffi. 2012. Modified energy cascade model adapted for a multicrop lunar greenhouse prototype. Advances in Space Research, 50: 941-951

Crane, T.C., C. Kubota, J.L. West, M.A. Kroggel, B.C. Wertheim, and C.A. Thomson. 2011. Increasing the vegetable intake dose is associated with a rise in plasma carotenoids without modifying oxidative stress or inflammation in overweight or obese postmenopausal women. J. Nutrition.141:1827-1833.

Crowe, B., S. Attalah, S. Agrawal, P. Waller, R. Ryan, J. Van Wagenen, A. Chavis, J. Kyndt, M. Kacira, K. L. Ogden, M. Huesemann. 2012. A comparison of Nannochloropsis salina growth performance in two outdoor pond designs: conventional raceways versus the ARID pond with superior temperature management. International Journal of Chemical Engineering, Vol. 2012, Article ID 920608, 9 pages. doi:10.1155/2012/920608

Linker, R., M. Kacira, A. Arbel. 2011. Robust climate control of a greenhouse equipped with variable-speed fans and a variable-pressure fogging system. Biosystems Engineering, 110(2): 153-167.

Matsuda, R., C. Kubota, M.L. Alvarez, and G. Cardineau. 2012. Effect of high electrical conductivity of hydroponic nutrient solution on vaccine protein content in transgenic tomato. HortTechnology. 22:362-367.

Sase, S., M. Kacira, T. Boulard, L. Okushima. 2012. Determination of porosity parameters for tomato canopy: An experimental study in a wind tunnel. Transactions of the ASABE. (Accepted)

Striemer, G.M., D. L. Story, A. Akoglu and M. Kacira. 2011. A node and network level self-recovering distributed wireless sensor architecture for real-time crop monitoring in greenhouses. Transactions of ASABE, 54(4): 1521-1527.

Villarreal-Guerrero, F., M. Kacira, E. Fitz-Rodríguez, C. Kubota, G.A. Giacomelli, R. Linker and A. Arbel. 2012. Comparison of three evapotranspiration models for a greenhouse cooling strategy with natural ventilation and variable high pressure fogging. Scientia Horticulturae. 134:210-221.

Villarreal-Guerrero, F., M. Kacira, E. Fitz-Rodriguez, R. Linker, C. Kubota, G. Giacomelli, A. Arbel. 2012. Simulated performance of a greenhouse cooling control strategy with natural ventilation and fog cooling. Biosystems Engineering. 111:217-228.

Waller, P., R. Ryan, M. Kacira, P. Li. 2012. Algae raceway integrated design (ARID) for optimal temperature management. Biomass and Bioenergy. (In Press)

Yang, Z.-C.*, C. Kubota*, P.-L. Chia, and M. Kacira. 2012. Effect of end-of-day far-red light from a movable LED fixture on squash rootstock hypocotyl elongation. Scientia Horticulturae 136:81-86. [*equally contributing to the work]

(2) Conference proceedings and other articles

Fitz-Rodríguez, E., M. Kacira, F. Villarreal-Guerrero, G. Giacomelli, C. Kubota, R. Linker, and A. Arbel. 2012. Neural network predictive control in a naturally ventilated and fog cooled greenhouse. Acta Horticulturae 952:45-52.

Giacomelli, G., G. Boscheri, R. Furfaro, M. Kacira, C. Lobascio, L. Patterson, P. Sadler, M. Pirolli, R. Remiddi, D. Story, M. Thangavelu, M. Catalina. 2012. Bio-regenerative Life Support System Development for Lunar/Mars Habitats. 42nd Int. Conf. on Environmental Systems, July 15-19, San Diego, California.

Hernández, R. and C. Kubota. 2012. Tomato seedling growth and morphological responses to supplemental LED lighting red:blue ratios under varied daily solar light integrals. Acta Horticulturae (in press).

Kacira, M., G. Giacomelli, R.L. Patterson, R. Furfaro, P.D. Sadler, G. Boscheri, C. Lobascio, M. Lamantea, R.M. Wheeler, and S. Rossignoli. 2012. System dynamics and performance factors of UA-CEAC lunar greenhouse prototype bioregenerative life support system. ActaHorticulturae, 952: 575-582.

Kroggel, M., W. Lovichit, C. Kubota, and C. Thomson. 2012. Greenhouse baby leaf production of lettuce and Komatsuna in semi-arid climate: seasonal effects on yield and quality. Acta Horticulturae 952:827-834.

Kubota, C. 2012. Environmental control technologies to improve greenhouse product quality. Acta Horticulture 952:843-851.

Kubota, C. 2012. Use of grafted vegetable seedlings in North America and Europe - Can Japan take advantage of this growing international business opportunity? Farming Mechanization 5:17-22. (in Japanese)

Kubota, C., P. Chia, Z. Yang, and Q. Li. 2012. Applications of far-red light emitting diodes in plant production under controlled environments. Acta Horticulturae 952:59-66.

Mitchell, C.A., A.J. Both, C.M. Bourget, J.F. Burr, C. Kubota, R.G. Lopez, R.C. Morrow, and E.S. Runkle. 2012. LEDs: The future of greenhouse lighting! Chronica Horticulturae 52: 6-12.

Patterson, R. L., G.A. Giacomelli, M. Kacira, P.D. Sadler, R.M. Wheeler, , and. 2012. Description, operation and production of the South Pole food growth chamber. ActaHorticulturae, 952:589-596.

Villarreal-Guerrero, F., M. Kacira, E. Fitz-Rodríguez, G. Giacomelli, R. Linker, C. Kubota, and A. Arbel. 2012. Simulation of fixed and variable fogging rates in a naturally ventilated greenhouse: Water and energy savings and stability of climate. Acta Horticulturae 952:37-44.

(3) Book chapters

Kubota, C. 2012. Grafting with vegetable plants. In: C.A. Beyl and R.N. Trigiano (eds.) Plant Propagation Concepts and Exercises, 2nd Edition. CRC Press (in press)

Kubota, C., A. De Gelder, and M. Peet. 2012. Greenhouse tomato production. In: E. Heuvelink (ed.) Tomatoes, 2nd Edition. CABI Publishing (in press)

Montero, J. I., M. Teitel, E. Baeza, J.C. Lopez, M. Kacira. 2012. Greenhouse design and covering materials. Chapter 1 "Good agricultural practices (GAPs) principles for greenhouse vegetable production in the Mediterranean region." FAO/ISHS book. (In Press)

7. Scientific and Outreach Oral Presentations

Kacira, M. 2012. Advanced monitoring and control of greenhouse system for optimized resource use efficiency. Agronomy Week Conference, Faculty of Agronomy, University of San Luis Potosi, San Luis Potosi, Mexico, February 2012. (Keynote Lecture)

Kacira, M. 2012. Engineering CEA systems for sustainable production. Arid-Land Agricultural Research Center (ALARC), Maricopa, AZ, June 2012.

Kacira, M. 2012. Greenhouse environmental control. 12th Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April 9-13, 2012.

Kacira, M. 2012. Greenhouse structures and design. 12th Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April 9-13, 2012.Kacira, M. 20112.Sensor and control basics: Data acquisition and instrumentation in Controlled environment agriculture. 12th Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April 9-13, 2012.

Kacira, M. 2012. Solar PV system integrated off-grid greenhouse. 12th Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April 9-13, 2012.

Kubota, C. 2012. Plant factory – Challenges and opportunities. 12th Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April 9-13, 2012.

Kubota, C. 2012. Plant lighting basics and applications. 12th Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April 9-13, 2012.

Kubota, C. 2012. Use of grafted vegetable seedlings in North America and Europe - Can Japan take advantage of this growing international business opportunity? Special seminar of Plant Factory Association of Japan, Kashiwanoha, Japan, July 6th, 2012.

Tamimi, E. and M. Kacira. 2012. Analysis of climate uniformity in a naturally vented greenhouse equipped with high pressure fogging system using computational fluid dynamics. CIGR2012 International Conference of Agricultural Engineering, Valencia, Spain, July 8-11.

Villarreal-Guerrero, F., M. Kacira, E. Fitz-Rodríguez, G. A. Giacomelli, C. Kubota. 2012. A climate control strategy for naturally ventilated greenhouse with variable high pressure fogging: Evaluating energy and water savings, climate uniformity. CIGR2012 International Conference of Agricultural Engineering, Valencia, Spain, July 8-11.

8. Other relevant accomplishments and activities

N/A