

1. Impact Nuggets

- Kacira Lab developed a computer vision guided crop sensing and monitoring system and a methodology to monitor nutrient deficiency which could eventually save labor to monitor crop quality and yield, as well as improve resource use efficiency. The existing system's software capability is currently being improved for plant phenotyping studies.
- Dr. Kacira and his research team has been working on developing advanced climate control strategy to maintain desired air temperature and humidity in a naturally ventilated greenhouse equipped with variable high pressure fogging system. The initial computer simulations indicated promising results for water and energy savings using this system compared to fixed high pressure fogging system based on VPD control. The implementation of the developed algorithm with greenhouse experiments is currently under progress.
- The University of Arizona (Dr. Kubota) developed a photoautotrophic Arabidopsis culture protocol to distribute to basic plant scientists. This method allows normal physiology and growth of plants under in vitro environments.

2. New Facilities and Equipment

- Dr. Kubota acquired six LED panels with red and blue light emissions (CCS Inc., Kyoto, Japan) for her study on supplemental LED lighting for horticultural crops. A 1,000 sq ft greenhouse space was renovated to study the effect of light quality (B/R ratio) of supplemental LED lighting over vegetable seedlings.
- Drs. Kubota and Kacira developed a testing unit of movable LED light fixture using an ORBITEC far-red LED bar and a programmable motor drive to apply end-of-day far-red light over plant canopy in the greenhouse.
- Dr. Kacira has been working on integrated sensor network to monitor microalgae yield and health in realtime within PBR and open raceway systems. The research team has also been working on developing control strategy to optimize resource use (i.e. CO₂, air, feed water and nutrients) in the raceway system. The team has also been evaluating optical density sensors to monitor algae yield and health.

3. Unique Plant Responses.

- Dr. Kubota and her visiting scientist Dr. Zhenchao Yang tested end-of-day far-red light treatment by the moving LED light fixture. The response of squash rootstock hypocotyl was comparable to that treated by the stationary LED fixture. End-of-day light treatment is a non-chemical plant morphology control and the results showed that light environment design could become flexible by using movable fixtures.

4. Accomplishment Summaries

- University of Arizona Controlled Environment Agriculture Center (UA CEAC) organized the 10th Greenhouse Crop Production and Engineering Design Short Course (April 5-8, 2010) 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.
- UA CEAC inspired ~750 4th-8th graders at the Math and Sciences Experience Expo (May 7, 2010; Sierra Vista, AZ), presenting the biology and physics behind food production technologies used in controlled environment agriculture.
- Dr. Kubota completed her 6-month sabbatical leave in RIKEN Plant Science Center in Japan, establishing new collaboration to integrate multi-omics into her research under controlled environments. She has also developed a users manual for Photoautotrophic Arabidopsis Culture (PAC) for Arabidopsis users to set up experiments in tissue culture that allows normal plant growth environments.

5. Impact Statements

Not applicable this year.

6. Published Written Works

- Baeza, E., **M. Kacira**, J. Perez-Parra, J.C. Lopez, J. C. Gazquez, and J. I. Montero. 2010. Validation of CFD Simulations for Three Dimensional Temperature Distributions of a Naturally Ventilated Multispan Greenhouse obtained by Wind Tunnel Measurements. *Acta Horticulturae*. (In Press)
- Chia, P.-L. and **C. Kubota**. 2010. End-of-day far-red light quality and dose requirements for tomato rootstock hypocotyl elongation. *HortScience* 45:1501-1506.
- Fitz-Rodríguez, E., **C. Kubota**, **G.A. Giacomelli**, M.E. Tignor, S.B. Wilson, M. McMahon. 2010. Dynamic modeling and simulation of greenhouse environments under several scenarios: A web-based application. *Computers and Electronics in Agriculture* 70:105-116.
- Fitz-Rodríguez, E., J. Nelkin and **C. Kubota**. 2010. Use of disposable film sensor for analyzing uniformity of daily light integral inside a greenhouse. *Acta Horticulture* (in press)
- Justus, I. and **C. Kubota**. 2010. Effects of low temperature storage on growth and transplant quality of non-grafted and grafted cantaloupe-type muskmelon seedlings. *Scientia Hort.* 125:47-54.
- Kubota, C.** and M. Kroggel. 2010. Application of 1-MCP for long distance transportation of high quality tomato seedlings. *Acta Horticulturae* (submitted)
- Lee, J.-M., **C. Kubota**, S.J. Tsao, Z. Bie, P. Hoyos Echevarria, L. Morra, and M. Oda. 2010. Current status of vegetable grafting: Diffusion, grafting techniques, automation. *Scientia Horticulturae*. 127:93-105.
- Linker, R., **M. Kacira**, A. Arbel. 2011. Robust climate control of a greenhouse equipped with forced ventilation and a variable-pressure fogging system. *Biosystems Engineering*. (In Review)
- Louws, F.J., C.L. Rivard, and **C. Kubota**. 2010. Grafting fruiting vegetables to manage soilborne pathogens, foliar pathogens, arthropods and weeds. *Scientia Horticulturae*. 127:127-146.
- Matsuda, R. and **C. Kubota**. 2010. Variation of total soluble-protein content in fruit among six greenhouse tomato cultivars. *HortScience* 45:1645–1648.
- Matsuda, R., **C. Kubota**, M. L. Alvarez and G. A. Cardineau. 2010. Determining the optimal timing of fruit harvest in transgenic tomato expressing F1-V, a candidate subunit vaccine against plague. *HortScience*. 45:347–351.
- Story, D., **M. Kacira**, **C. Kubota**, A. Akoglu, L. An. 2010. Lettuce calcium deficiency detection with machine vision computed plant features in controlled environments. *Computers and Electronics in Agriculture*, 74(2): 238-243.
- Story, D., **M. Kacira**, **C. Kubota** and A. Akoglu. 2010. Morphological and Textural Plant Feature Detection using Machine Vision for Intelligent Plant Health, Growth and Quality Monitoring. *Acta Horticulturae*. (In Press)
- Striemer, G.M., D. Story, A. Akoglu, **M. Kacira**. 2010. A Node and Network Level Self-Recovering Distributed Wireless Sensor Architecture for Real Time Monitoring in Greenhouses. *Transactions of ASABE*. (In Review)
- Waller, P., R. Ryan, **M. Kacira** and P. Li. 2011. Algae Raceway Integrated Design (ARID) for optimal temperature management, Biomass and Bioenergy. (In Review)

7. Scientific and Outreach Oral Presentations

- Beretta, A., V. Bornisacci, G. Boscheri, S. De Pascale, R. Furfaro, G. Giacomelli, L. Grizzaffi, M. Kacira, M. Lamantea, Boscheri, G., Furfaro, R., Giacomelli, G., Grizzaffi, L., Kacira, M., Lamantea, M., Lobascio, C., Patterson, R.L., Sadler, P. 2010. Evaluation of bio-regenerative life support systems in the frame of a concurrent international cooperation. AIAA Paper No. AIAA-2010-6202, 40th International Conference on Environmental Systems, Barcelona, Spain. (Oral Presentation)
- C. Lobascio, R.L. Patterson, M. Pirolli, S. Rossignoli, P. Sadler. 2010. International Collaboration on Bioregenerative
- Gregory, M. S., D. Story, A. Akoglu, M. Kacira. 2010. A Node and Network Level Self-Healing Distributed Wireless Sensor Architecture for Greenhouse Based Plant Monitoring Systems. ASABE Paper No. 1009468. St. Joseph, Michigan. (Oral Presentation)
- Guerrero, F. V., M. Kacira, E. F. Rodriguez, R. Linker, A. Arbel, C. Kubota, G. Giacomelli. 2010. Developing a Control Strategy for Greenhouses Equipped with Natural Ventilation and Variable Pressure Fogging: Evapotranspiration Models and Simulated Comparison of Fixed and Variable Pressure Fog Cooling. ASABE Paper No. 1009388. St. Joseph, Michigan. (Oral Presentation)
- Kacira, M. 2010. Engineering Concerns and Opportunities for Sustainable Greenhouse Systems. Presented at the Scholar in Residence Program at Johnson County Community College, Kansas City, KA, 10/1/2010. (Invited Speaker)
- Kacira, M. 2010. Greenhouse Environmental Control. The 10th Greenhouse Crop Production and Engineering Design Short Course, April 5-8, Tucson, Arizona.

- Kacira, M. 2010. Greenhouse Structures and Design. The10th Greenhouse Crop Production and Engineering Design Short Course, April 5-8, Tucson, Arizona.
- Kacira, M. 2010. Improving Production Quality and Resource Use Efficiency by Plant Sensing and Monitoring. Presented at the Scholar in Residence Program at Johnson County Community College, Kansas City, KA, 10/11/2010. (Invited Speaker)
- Kacira, M. 2010. Sensor and Control Basics. The10th Greenhouse Crop Production and Engineering Design Short Course, April 5-8, Tucson, Arizona.
- Kacira, M. 2010. Sustainable Controlled Environment Plant Production Systems: Challenges and Opportunities. Presented at University of Arizona Aerospace and Mechanical Engineering Department Seminar Series, 8/26/2010. (Invited Speaker)
- Kacira, M. 2010. Telepresence and Plant Health/Growth Monitoring. Appeared on Emmy-Award winning program "WaveLengths" hosted by Vicki Chandler. PBS, Channel 6, Tucson, AZ on 10/28/2010.
- Kubota, C. 2010. Enhancing produce quality and nutritional value of greenhouse crops. The10th Greenhouse Crop Production and Engineering Design Short Course, April 5-8, Tucson, Arizona.
- Kubota, C. 2010. Trends and key technologies in US greenhouse tomato production. Agro-Innovation Expo, November 25-27, Makuhari, Japan.
- Rodriguez, E. F., M. Kacira, F. V. Guerrero, C. Kubota, G. Giacomelli, R. Linker, A. Arbel. 2010. Dynamic Response and Environmental Uniformity of a Naturally Ventilated Greenhouse Cooled with a Variable-Pressure Fogging System. ASABE Paper No. 1009436. St. Joseph, Michigan. (Oral Presentation)
- Story, D., M. Kacira, C. Kubota, A. Akoglu, L. An. 2010. Nutrient Deficiency Detection with Machine Vision in Controlled Environments. Presented at the 2010 International Conference of Institute of Biological Engineering, Cambridge, Massachusetts, 3/5/2010. (Invited Oral Presentation)
- Systems for Space and Earth Applications. 4th International Workshop: "Agrospace: Controlled Environment Agriculture from Earth to Space and Back," Sperlonga, Italy. 5/21/2010.

8. Other relevant accomplishments and activities

- Controlled Environment Agriculture Center (CEAC) was recognized at the University of Arizona Leading Edge at Innovation Day (March 15, 2010).
- New Website; "Vegetable Grafting Information Website". (<http://cals.arizona.edu/grafting>)
- New DVD; "Vegetable Grafting – Learning How to Graft Tomato and Cucurbits"
- Patent. Waller, P., R. Ryan, M. Kacira, P. Li. 2010. Aquaculture Raceway Integrated Design (ARID). US Patent US2011/0023360 A1.
- New Website; "Prototype Lunar Greenhouse" Information Website
- Continuing the NASA Steckler Space Grant Lunar Greenhouse Prototype for Bioregenerative Life Support Systems (Phase II) to evaluate a BLSS approach for a sustained human surface presence on the Moon (or Mars) by development of poly-culture crop production, system mass balances, and flow of input/output resources, biomass recycling, energy generation, and monitoring/control with non-contact sensing and telepresence technologies. International collaboration. Public outreach and education. Co-PI's Gene Giacomelli, Murat Kacira and Roberto Furfaro all of UA, Phil Sadler, Sadler Machine Company. Support from John Hogan, NASA-AMES; international collaborators Thales Alenia Spacio Italy; Aero-Sekur, S.p.A.; Univ of Naples Federico II; USC- Dept of Astronautical Eng'r; NSF/Office of Polar Programs (NSF/OPP); MMARS; Moon Mars Atacama Res Sta (Chile); Pima Com Co; Safford Middle School.