NCERA-101 Station Report 2014

THE UNIVERSITY OF ARIZONA

1. New Facilities and Equipment.

- CEAC obtained a new spectroradiometer with 300-1100 nm wavelength measurement range.
- David Story (PhD candidate) and Kacira developed a multi-spectral based machine vision system for crop health and growth monitoring.
- Fei Jia (PhD candidate) and Kacira designed and built two multi-wavelength in-line optical density sensor system for real-time monitoring of microalgae concentration and health, and for control applications in PBR and raceway systems. The research is ongoing to evaluate the sensor unit.
- Kacira and Kubota had roof of 1100 ft^2 greenhouse glazed with a new glazing technology which has photo-selective and electricity producing capability. Crop responses and resource use efficiency are being evaluated under the new glazing technology.
- Kubota's new collaboration with Japanese organizations and industry brought an opportunity to evaluate a commercial unit for growing leafy crops indoor under LED lighting. This 65-ft^2 system is equipped with a vertically stacked multi-layer hydroponic growing system with LED lighting and CO_2 enrichment. The production unit was manufactured by Sankyo Frontier Co. (http://www.sankyofrontier.com/eng/), specialized with modular house building in Japan. Chiba University (http://www.h.chiba-u.jp/english/7index_e.htm) and Plant Factory Association of Japan (http://npoplantfactory.org/) are supporting the project and will initiate a student and faculty exchange program around this high-tech CEA.
- Hernandez, R. (Postdoc) and Kubota developed a new plant LED testing lab to evaluate plant responses to different light qualities. The facility is currently used for testing varied B:R ratios for different crop species.
- A greenhouse (2091-C) was renovated (Giacomelli, Song Gao) to include sand bed, top drip hydroponic growing system for root zone microbiological studies for lettuce.
- A greenhouse (high tunnel-N) was renovated (Hernandez, E., undergraduate & Giacomelli) to include deep water culture, floating bed hydroponics for lettuce production studies.

2. Unique Plant Responses.

- We [Jensen, Giacomelli, Kubota and Kacira] evaluated effects of organic liquid fertilizer obtained from food waste on overall qualitative yield and quality of several winter crops such as lettuce, broccoli, and kale growing in a sand culture system in a high tunnel greenhouse. The fresh weight based yield data showed no significant differences for all lettuce varieties (total five) grown between the inorganic and organic fertilizer fed group plants. The yields of organic fertilizer fed Kale were slightly higher than those grown with inorganic fertilizer. There were no significant differences for number of leaves for all lettuce varieties, Kale and Broccoli between the organic and inorganic fertilizer fed plants. The data showed that Anthocyanin levels were slightly higher especially in the colored lettuce varieties. There were no significant differences in Lutein and Beta Carotenoids. The data based on percent sample dry weights indicated that there were slightly higher dry weight percentages from the organic liquid fertilizer fed group plants.

3. Accomplishment Summaries.

- As part of graduate student (D. Story) research project in Kacira Lab, a methodology from a multi-camera based machine vision system was developed and evaluated to timely identify crop water stress. The developed methodology consisting of multiple variables determined the locality of the emerging water stress as good as visual stress detection with lettuce plants, dealing with the uncertainty of light intensities and incidents of shadows amongst the plant canopy in a greenhouse setting. A web based platform was also developed and implemented to serve as a decision support and management module performing as interface between the NASA Steckler Space Grant Program's Lunar Greenhouse (LGH) Prototype (as BLSS) with capabilities of real time data and system monitoring, data analysis, access point for operational and processed data, system alarms setting and monitoring, and inputs/discussions from system operators for improved management of the LGH system. The development of this web based platform also targeted future transfer and potential applications of decision support and production system monitoring to improve food production capabilities and resource utilization efficiency of Earth based CEA production systems.
- Kacira Lab designed, built and completed evaluating an off grid greenhouse system (OGGH) powered by solar energy as an alternative food production system for deployment in challenged regions which would not have steady and immediate access to resources for production. Polly Juang (MS Student) worked with cherry tomatoes grown in sand culture in the OGGH system and demonstrated that production yields from OGGH were comparable to that of the grid tied system (GCGH), and were 0.96 and 0.95 kg m^{-2} $week^{-1}$, respectively. The research also determined that the integrated OGGH produced 19.8 MJ m^{-2} with its PV power generation system while greenhouse system demanding 18.3 MJ m^{-2} energy. Energy productivity of the OGGH was 85.6 kg MJ^{-1}.
- UA-CEAC organized the 13th Greenhouse Crop Production and Engineering Design Short Course (April 9-12, 2013) with ~100 participants. Hands-on workshops were given to attendees during the short course. These workshops included demonstrating vegetable grafting techniques, hydroponics crop production and systems basics, greenhouse sensors and instrumentation basics with theory and practical use.
- Rorabaugh, Lewis & Giacomelli organized the 3rd Annual Intensive Greenhouse Tomato and Lettuce Crop Production Short Course (January 5-12, 2014) with 32 participants. The program include morning classroom lectures and afternoon hands-on practice with crops.
- Two one-day workshops of 'Arizona Strawberry Day' were held (December 7, 2013 and February 22, 2014) attracting 62 participants from states of AZ, CA, CO, NM, OH, OR, WA and Mexico.

4. Impact Statements.

- Multi-camera and variable based machine vision system and developed methodology is a unique technology advancement which can be suited for realtime monitoring of crops, crop diagnostics, and stress locality detection in controlled environments based food production systems, potentially improving production quality and crop management. The system can also be used as part of a greenhouse based plant phenotyping system significantly reducing the time it takes to collect and analyze the data and laborious work required for data collection for phenotyping.
- Off-grid greenhouse food production system (with 1500 m^2 greenhouse foot print) generated tomato produce yields comparable to those from a grid-tied system while eliminating the need of energy from the grid (18.3 MJ m^{-2}), contributing to greening the greenhouse food production system, eliminating substantial amount of CO2 emissions.

5. Published Written Works.

Book Chapters

Kubota, C., A. Balliu, and S. Nicola. 2013. Quality of planting materials. In: Good Agricultural Practices for Greenhouse Vegetable Crops. Food and Agricultural Organization of the United Nations. pp 355-378.

Montero,J. I., M. Teitel, E. Baeza, J. C. Lopez and M. Kacira. 2013. Greenhouse designs and covering materials. In: Good Agricultural Practices for Greenhouse Vegetable Crops. Food and Agricultural Organization of the United Nations. pp 35-62.

Refereed Journal Articles

Lewis, M., C. Kubota, R. Tronstad, and Y.-J. Son. 2014. Scenario-based cost analysis for vegetable grafting nurseries of different technology and size. HortScience (accepted for publication)

Meng, C., X. Dong, Y.-J. Son, C. Kubota, M. Lewis, and R.E. Tronstad. 2014. An integrated simulation and AHP approach to vegetable grafting operation design. Computers and Electronics in Agriculture. 102:73-84.

Tamimi, E., M. Kacira, C. Choi, and L. An. 2013. Analysis of climate uniformity in a naturally ventilated greenhouse equipped with high pressure fogging system. Transactions of ASABE, Vol. 56(3): 1241-1254. (*ASABE Superior Paper Award*)

Villarreal-Guerrero, F., M. Kacira, E. Fitz-Rodríguez, R. Linker, G. A. Giacomelli, A. Arbel, C. Kubota. 2013. Implementation of a greenhouse cooling strategy with natural ventilation and variable fogging rates. Transactions of ASABE. Vol. 56(1): 295-304.

Lee, I.B., J. Pascual, P. Bitog, S. Hong, I. Seo, K. Kwon, T. Bartzanas, M. Kacira. 2013. The past, present and future of CFD for agro-environmental applications, Computers and Electronics in Agriculture. Vol. 93: 168‑183.

Refereed Conference Proceedings Articles

Hernández, R. and C. Kubota. 2014. LEDs supplemental lighting for vegetable transplant production: spectral evaluation and comparisons with hid technology. Acta Horticulturae (in press)

Hernández, R., A. Dragotakes and C. Kubota. 2014. Pulsing effects of supplemental LED lighting on cucumber seedlings. Acta Horticulturae (in press)

Meng, C., S. Kim, Y.-J. Son, and C. Kubota. 2013. A SYSML-based simulation model aggregation framework for seedling propagation system. Proceedings of the 2013 Winter Simulation Conference, Washington DC, 8–11 December 2013

Juang, P. and M. Kacira. 2013. System dynamics of a photovoltaic integrated greenhouse. ActaHorticulturae (In Press)

Giacomelli, G. 2013. “New Technologies On Environmental Control, Energy-Saving and Crop Production in Greenhouses in USA” (Invited Oral Presentation, GreenSys 2013, Jeju, S. Korea)

Story, D., M. Kacira, L. An, A. Ali and J. Y. Yoon. 2013. Automated machine vision guided plant monitoring system for greenhouse crop diagnostics. ActaHorticulturae (In Press)

Villarreal-Guerrero, F., M. Kacira and J. Flores-Velazquez. 2013. Comparative performance of a greenhouse cooling strategy with natural ventilation and fogging under different outside climates. ActaHorticulturae (In Press)

Bartzanas, T., M. Kacira, T. Boulard, J. C. Roy, H. Fatnassi, P. E. Bournet, N. Katsoulas and C. Kittas. 2013. The use of user define functions in CFD simulations for greenhouse environment. ActaHorticulture (In Press) (Invited Oral Presentation, GreenSys 2013, Jeju, S. Korea)

Fatnassi, H., T. Boulard, T. Bartzanas, N. Katsoulas, M. Kacira and C. Poncet. 2013. CFD modeling of microclimate in the leaf boundary layer, ecological niche of pests. ActaHorticulturae (In Press)

Other Creative Works

Sheehy, C. and G. Giacomelli, 2014. "Earthlight" Documentary and the Lunar Greenhouse Prototype. Documentary created by C. Sheehy (videographer) and Giacomelli (NASA Steckler Technical PI) for PBS and social media campaign. The documentary features interviews with NASA scientists (Ray Wheeler, KSC), UA researchers (M. Kacira, R. Furfaro, G. Giacomelli) and students (M. Downing, C. Hall, T, Jensen, E. Hernandez, M. Yanes, S. Gellenbeck) exploring the urgency of sustainable living and how projects like the lunar greenhouse are key to maintaining our planet. "Earthlight" premiered at Loft Cinema, Tucson, AZ May 7th; and will be honoring the 45th year anniversary of the first Apollo landing in July. http://cals.arizona.edu/earthlight/ twitter @earthlightdoc and facebook.com/earthlightdoc

Hydroponic Strawberry Information Website: http://cals.arizona.edu/strawberry

Kacira, M.2013. Choose The Right Greenhouse Style. Greenhouse Grower Magazine. http://www.growingproduce.com/article/32536/choose-the-right-greenhouse-style.

Kacira, M. 2013. Natural Ventilation And Fog Increase Cooling Efficiency. Greenhouse Grower magazine. http://www.greenhousegrower.com/structures-equipment/natural-ventilation-and-fog-increase-cooling-efficiency/

Scientific and Outreach Presentations

Giacomelli, G. 2013. Technological Opportunities in Indoor Food Growing Systems: Working examples of South Pole and Moon Applications. Global Forum for Innovations in Agriculture (GFIA 2014)., Abu Dhabi National Exhibition Centre (ADNEC), UAE, 3-4 February.

Juang, P. and M. Kacira. 2013. System dynamics of a photovoltaic integrated greenhouse. GreenSys 2013, Jeju, S. Korea. [Invited Oral Presentation]

Story, D., M. Kacira, L. An, A. Ali and J. Y. Yoon. 2013. Automated machine vision guided plant monitoring system for greenhouse crop diagnostics. GreenSys 2013, Jeju, S. Korea.

Villarreal-Guerrero, F., M. Kacira and J. Flores-Velazquez. 2013. Comparative performance of a greenhouse cooling strategy with natural ventilation and fogging under different outside climates. GreenSys 2013, Jeju, S. Korea.

Bartzanas, T., M. Kacira, T. Boulard, J. C. Roy, H. Fatnassi, P. E. Bournet, N. Katsoulas and C. Kittas. 2013. The use of user define functions in CFD simulations for greenhouse environment. GreenSys 2013, Jeju, S. Korea. [Invited Oral Presentation]

Fatnassi, H., T. Boulard, T. Bartzanas, N. Katsoulas, M. Kacira and C. Poncet. 2013. CFD modeling of microclimate in the leaf boundary layer, ecological niche of pests. GreenSys 2013, Jeju, S. Korea.

Short course

Greenhouse Crop Production and Engineering Design Short Course. April 7-12, 2013. [G. Giacomelli, P. Rorabaugh, C. Kubota, M. Kacira, M. Jensen, K. Fitzsimmons]

Intensive Greenhouse Tomato and Lettuce Crop Production Short Course. January 5-12, 2014. [P. Rorabaugh, M. Lewis, G. Giacomelli]

6. Other relevant activities or information.

Kacira, M. (Committee Member). International Committee for Controlled Environment Guidelines: Guidelines for Monitoring and Reporting Environmental Parameters for Experiments in Greenhouses.