



NCERA-101 Station Report 2017 – The University of Arizona

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Reporting period: June 30, 2016 – April 09, 2017

1. New Facilities and Equipment (including sensors, instruments, and control systems purchased/installed)

- A 100m² greenhouse bay was renovated by Myles Lewis (Arizona Vegetable Growers) and Dr. Gene Giacomelli, to provide intensive workshops on hydroponic lettuce production.
- The UA-CEAC established a new multi-tier vertical farm based research, education, extension and outreach facility (UAg Farm) (750 ft²). The project (PI Kacira) was funded by Water, Environmental and Energy Solutions program, in part by UA-CEAC facilities maintenance funds, along with in-kind support by industrial collaborators Illumitex, IndoorHarvest, HortAmericas. The goal of the project and this program is to conduct engineering and science based research to address challenges and help advancing technology and crop production applications with indoor growing under artificial lighting, to provide experiential educational opportunities for students, to educate and inform growers and public on indoor growing systems.
- Kacira Lab custom designed, built and implemented a data acquisition and graphical user interface system, in the indoor vertical farm facility (UAg Farm), that enables real-time monitoring of key environmental variables including air temperature, relative humidity, CO₂, light intensity from aerial environment and pH, electrical conductivity, dissolved oxygen from nutrient solution as well as monitoring of resource use (e.g. energy, water, CO₂), while controlling CO₂ injections. A custom design Dash Board also serves as graphical user interface for the system operators to access these monitored and recorded variables for improved system and operational managements and resource use.
- A 20-foot long standard shipping container was retrofitted by the Cuello Biosystems Engineering Laboratory as a modular vertical farming unit for educational purposes, sponsored by The University of Arizona Green Fund. Dubbed the Arizona Green Box, the unit contains vertically stacked hydroponic cultivation systems built by a group of participating students, called "Cats in the Green Box." Through this project, an original vertical farming cultivation system specifically designed for vertical farming, the V-Hive Green Box, has just been prototyped and for which a patent disclosure has just been submitted.

2. Unique Plant Responses

3. Accomplishment Summaries

- Kacira lab designed and help implementing a vertical air flow and distribution system workinwith industrial collaborator, to be used in a multi-tier vertical farm system for transplant production, with improved climate uniformity and providing desired air current speeds for the production.
- Kacira Lab enhanced design of the multi-wavelength based optical density sensors to serve as in-situ sensor unit, for algae biomass growth and health monitoring in real-time. A neural-networks based predictive model was developed aiming to timely indicate anomaly in growth and health of algae and help making corrective actions to prevent algae crushing or saving the biomass by harvesting.
- UA CEAC organized the 16th Greenhouse Crop Production and Engineering Design Short Course (April 3-7, 2017) with 100 participants. Hands-on workshops were given to attendees during the short course. These workshops included demonstrating hydroponics crop production and systems basics, greenhouse sensors and instrumentation basics with theory and practical use.
- Online non-credit professional course 'Greenhouse Plant Physiology and Technology' was offered in October - December, 2016 (9 weeks, 29 enrollment).
- One-day private strawberry training was offered to 4 individuals during the 2016/2017 season.
- One-day private custom training was offered to 9 individuals during the 2016/2017 season
- Organized and hosted National Greenhouse Manufacturers Association (NGMA) Annual Meeting tour at UA-CEAC which included professional interaction and introduction of all CEA students with the 50 companies represented. April 11th, Tucson, AZ
- The Cuello Biosystems Engineering Laboratory successfully tested the hydrodynamic characteristics and algae biomass production in the Accordion Air-Loop Bioreactor, the third in the series of the Lab's patented Accordion Photobioreactors
- Cuello and the Association for Vertical Farming (AVF) have agreed to launch the Vertical Farming Global Sustainability Registry Network (or Vertical Farming SURE Network), whose aims include
- (1) to enable Vertical Farming companies and institutions to voluntarily self-report their own yearly Vertical Farming sustainability achievements; (2) to provide each participating Vertical Farming company or institution due recognition for its annual effort in helping the Vertical Farming industry collectively reach its significant sustainability potential and goals; (3) to provide each participating Vertical Farming company or institution due recognition for its effort in furthering or fulfilling its corporate social responsibility (CSR) in advancing environmental, economic and social sustainability; (4) to record, monitor, analyze and publish development trends in sustainability-based productivities among various types of Vertical Farms that make up the global Vertical Farming industry; and, (5) to provide annual guides and recommendations for the various types of Vertical Farms in the industry to help further advance their sustainability-based productivities. The Vertical Farming SURE Network is scheduled for formal launching later this year.

4. Impact Statements

5. Published Written Works

Books/Book Chapters

Cuello, J.L., T. Hoshino, S. Kuwahara and C. Brown. 2016. Scale Up – Bioreactor Design and Culture Optimization. In *Biotechnology for Biofuel Production and Optimization*. Eckert and Trinh (eds.). Elsevier. 497-511.

Refereed Journal Articles

Kubota, C., C. Meng, Y.J. Son, M. Lewis, H. Spalholz, and R. Tronstad. 2017. Horticultural, systems-engineering and economic evaluations of short-term plant storage techniques as a labor management tool for vegetable grafting nurseries. *PLOS ONE* <http://dx.doi.org/10.1371/journal.pone.0170614>

Spalholz, H. and C. Kubota. 2017. Rootstock affected in- and post storage performance of grafted watermelon seedlings at low temperature. *HortTechnology*, 27:93-98

Hernández, R., T. Eguchi, M. Deveci, and C. Kubota. 2016. Tomato seedling physiological responses under different percentages of blue and red photon flux ratios using LEDs and cool white fluorescent lamps. *Scientia Horticulturae*, 213:270-280

Zhang, Y., Kacira, M., and An, L. 2016. A CFD Study on Improving Air Flow Uniformity in Indoor Plant Factory System. *Biosystems Engineering*, 147: 193–205.

Katsoulas, N., A. Elvanidi, K. P. Ferentinos, M. Kacira, T. Bartzanas, C. Kittas. 2016. Crop reflectancemonitoring as a tool for water stress detection in greenhouses: A review. *Biosystems Engineering*, 151: 374-398.

Refereed Conference Proceedings Articles

Garcia, K. and C. Kubota. 2017. Physiology of strawberry plants under controlled environment: Diurnal change in leaf net photosynthetic rate. *Acta Horticulturae* (in press).

Garcia, K. and C. Kubota. 2017. Flowering responses of North American strawberry cultivars. *Acta Horticulturae* (in press).

Kroggel, M. and C. Kubota. 2017. Controlled environment strategies for tipburn management in greenhouse strawberry production. *Acta Horticulturae* (in press).

Kacira, M., M. Jensen, T. Robie, S. Tollefson, G. Giacomelli. 2016. Use resources wisely: waste management and organic liquid fertilizer use in greenhouse production system. *Acta Horticulturae* [In Press]

Romero, E. J. B., and Kacira, M. 2016. Greenhouse technology for cultivation in arid and semi-arid regions. *Acta Horticulturae* [In Press]

Zhang, Y. and M. Kacira. 2016. Improving crop canopy boundary layer dynamics in multi-tier indoor plant factory system. *Acta Horticulturae* [In Press]

Other Creative Works

Website and social media

CEAC Website: <http://ceac.arizona.edu/>

CEAC Facebook: <https://www.facebook.com/UA.CEAC>

Facebook for Controlled Environment Plant Physiology and Technology Lab:
<https://www.facebook.com/CEPPTLAB/>

Strawberry information site: <http://cals.arizona.edu/strawberry>