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

- The UA CEAC (PI Kacira) and several organizations (technology/industry partners) launched a new multi-tier vertical farm based research, education, extension and outreach facility (UA VF-REEO) (750 ft²). The aims of the UA VF-REEO programs are to develop new partnerships with industry including horticultural lighting technology providers, vertical farming system designers and manufacturers, climate control and sensor technology developers and suppliers, vertical farming system designer and providers, hydroponics systems and supplies providers, entrepreneurs, consultants, and also educators. The research activities envisioned include, but not limited to, plant physiology, plant responses, plant phenotyping, engineering, computer sciences, economics and life cycle assessments with multi-disciplinary research teams.

- A 200m² greenhouse bay was renovated by Dr. Stacy Tollefson, ABE Assistant Professor of Practice, to provide organic hydroponic nutrition for greenhouse tomato production in collaboration with Sonoran Hydroponics, Tucson, AZ.

- A web-based application ‘VPD calculator’ was developed by Dr. Kubota. This can be saved in the home-screen of smart phones to use as app. A simple computation is based on ASHRAE and returns vapor pressure deficit (kPa) and humidity density (g m⁻³) from selected air temperature and relative humidity under 101.3 kPa atmospheric pressure. [http://cals.arizona.edu/vpdcalc/](http://cals.arizona.edu/vpdcalc/)
2. Unique Plant Responses

- Unique diurnal declines in photosynthetic capacity were found for strawberry plants grown under greenhouse controlled environment, possibly due to negative feedback in photosynthesis in some periods of winter/spring production of strawberry. Our preliminary results supported that imbalance of sink and source was the primary factor in the negative-feedback of photosynthesis. Therefore, morning hours are critical time for promoting photosynthesis when negative feedback of photosynthesis is occurring and could lead to develop practices in strawberry production in CEA in order to maximize production. Research findings were summarized and presented by Dr. Kubota and her graduate student (K. Garcia) at the 8th International Strawberry Symposium in Quebec, Canada (August, 2016).

3. Accomplishment Summaries

- As part of the SCRI vegetable grafting project funded by USDA, Dr. Kubota organized two international field trips to Asia (Taiwan and Japan) in August 2015 and Europe (Italy) in March 2016. A total of 23 participants from US industry and academia had visited commercial grafting nurseries to see their technologies of controlled environment and automation, including indoor plant production system and grafting robot. Trip reports are available at http://www.vegetablegrafting.org/resources/solanaceae/prepare-solanaceae/publications-and-presentations/
- In collaboration with an industrial partner, Kacira Lab evaluated a unique greenhouse design incorporating a spectral separation film for enabling PAR for crop and harvesting NIR for potential energy production while demonstrating production of acceptable yield and maintain quality with lettuce crop.
- Kacira Lab developed and validated computational fluid dynamics models capable of providing detailed information on climate uniformity, within several hours of computational time compared to months of experimental and numerical analysis, saving costs and labor required, offering design recommendations for industrial partner using multi-tier based vertical farm systems
- Kacira Lab further enhanced the novel multi-wavelength based optical density sensors, for algae biomass growth and health monitoring in real-time. The sensor unit enabled autonomous system operations compared to traditional lab spectrofluorometers requiring several hours to make measurements and interpret the results for decision making and system operation with indoor or outdoor based microalgae production systems. A full U.S. patent has been filed for the sensor unit.
- UA CEAC organized the 15th Greenhouse Crop Production and Engineering Design Short Course (March 22-24, 2016) with 70 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 August - October, 2015 (9 weeks, 25 enrollment).
- One-day private strawberry training was offered to 8 individuals during the 2015/2016 seasons.
- 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
• Three graduate students (5 MS) were graduated with degrees with focus on Controlled Environment Agriculture. [Garcia, Hall, Bertsch, Kacheris and Quinlan]

4. Impact Statements

• The 5-year project of SCRI vegetable grafting (Kubota) brought multiple new businesses of grafting nurseries and robotics investing into the U.S. market. One example is a newly opened ~$7 million greenhouse nursery complex of a new company TriHishtil (Mills River, NC) whose primary purpose is to sell grafted vegetable plants into the U.S. market starting in 2016. Another example is the first automated grafting operation for processing tomato industry in California developed in 2015 in collaboration with a seed company based in Israel (http://www.rootility.com/newsevents/rootility_appears).

• The greenhouse strawberry production research program (Kubota and Kroggel) helped to develop the capacity of commercially growing strawberries in greenhouse in the US. In AZ, a grower in Phoenix and Willcox areas (a total of 27 acres of greenhouse space) became the first AZ greenhouse strawberry producer for local market. There are also several projects nationwide conducted by different companies.

5. Published Written Works

Books/Book Chapters


Refereed Journal Articles

Eguchi, T. and C. Kubota. 2015. Cotyledonary axillary shoot control by fatty alcohol application for grafting tomato. HortTechnology. 25:569-574


**Refereed Conference Proceedings Articles**


**Other Creative Works**


**Website and social media**

CEAC Website: [http://ceac.arizona.edu/](http://ceac.arizona.edu/)

CEAC Facebook: [https://www.facebook.com/UA.CEAC](https://www.facebook.com/UA.CEAC)

Facebook for Controlled Environment Plant Physiology and Technology Lab: [https://www.facebook.com/CEPPTLAB/](https://www.facebook.com/CEPPTLAB/)

Strawberry information site: [http://cals.arizona.edu/strawberry](http://cals.arizona.edu/strawberry)