NCERA-101 Station Report 2016 – The University of Arizona

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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 ft^2). 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 200m^2 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/

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

Kubota, C. 2015. Plant factory business and R&D in the world – current status and perspectives -- North America. P.59-61, In: (T. Kozai, G. Niu, and M. Takagaki eds.) Plant factory: An indoor farming system for efficient quality food production. Elsevier, London, UK.

Kubota, C. 2015. Growth, development, transpiration and translocation as affected by abiotic environmental factors. P.151-164, In: (T. Kozai, G. Niu, and M. Takagaki eds.) Plant factory: An indoor farming system for efficient quality food production. Elsevier, London, UK.

Kubota, C. 2015. Biological factor management (1) Controlling algae. P.285-286, In: (T. Kozai, G. Niu, and M. Takagaki eds.) Plant factory: An indoor farming system for efficient quality food production. Elsevier, London, UK.

Refereed Journal Articles

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

Eguchi, T., R. Hernández, and C. Kubota. 2016. Far-red and blue light synergistically mitigate intumescence injury of tomato plants grown under UV-deficit light environment. HortScience. 51:712-719.

Hernández, R. and C. Kubota. 2015. Physiological, morphological, and energy-use efficiency comparisons of LED and HPS supplemental lighting for cucumber transplant production. HortScience. 50:351-357.

Hernández, R. and C. Kubota. 2016. Physiological responses of cucumber seedlings under different blue and red photon flux ratios using LEDs. Environ. Exp. Bot. 121:66-74.

Jia, F., M. Kacira, K. Ogden. 2015. Multi-Wavelength Based Optical Density Sensor for Autonomous Monitoring of Microalgae. Sensors, 15(9): 22234-22248. DOI:10.3390/s150922234

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

Refereed Conference Proceedings Articles

Eguchi, T., R. Hernández, and C. Kubota. 2016. End-of-day far-red lighting combined with blue-rich light environment to mitigate intumescence injury of two interspecific tomato rootstocks. Acta Horticulturae 1134:163-170.

Hernández, R., T. Eguchi, and C. Kubota. 2016. Growth and morphology of vegetable seedlings under different blue and red photon flux ratios using LEDs as sole source lighting. Acta Horticulturae 1134:195-200.

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. ActaHorticultrae [In Press]

Kozai, T., C. Kubota, M. Takagaki, and T. Maruo. 2015. Greenhouse environment control technologies for improving the sustainability of food production. Acta Horticulturae 1107:1-13.

Kubota, C., M. Kroggel, A.J. Both, J.F. Burr, and M. Whalen. 2016. Does supplemental lighting make sense for my crop? – Empirical evaluations. Acta Horticulturae 1134:403-411.

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

Ishii, M. S. Sase, H. Moriyama, L. Okushima, A. Ikeguchi, M. Hayashi, K. Kurata, C. Kubota, M. Kacira, and G.A. Giacomelli. 2016. Controlled enviornment agriculture for effective plant production systems in a semiarid greenhouse. Japan Agricultural Research Quarterly. 50:101-113.

Mitchell, C.A., J.F. Burr, R. Lopez, C. Kubota, R. Hernández, C. Currey, E.S. Runkle, R. Morrow, and A.J. Both. 2015. Light-emitting diodes in horticulture. Horticultural Review, 43:1-73.

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