NCERA-101 Station Report 2018 – The University of Arizona

Murat Kacira, Department of Agricultural and Biosystems Engineering, CEAC
Gene Giacomelli, Department of Agricultural and Biosystems Engineering, CEAC
Joel Cuello, Department of Agricultural and Biosystems Engineering, CEAC

Reporting period: April 09, 2017 – April 16, 2018

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

- The faculty [Dr. Gene Giacomelli], staff [Tilak Mahato, Neal Barto] and students of the UA-CEAC [University of Arizona-Controlled Environment Agriculture Center] and the Agricultural & Biosystems Engineering Department at CALS [College of Agriculture & Life Sciences] worked closely with industry contacts Ajay Jones [2015 - 17], Brad Hart and Stefanie Boe [2017 - present] of Monsanto Company to establish a new plant production procedure for growing corn in the greenhouse to develop the breeding lines required for developing new varieties of field corn, and to replace the less efficient, current practice of field production. An Ebb & Flood hydroponic nutrient delivery system was created, tested and demonstrated to successfully produce mature seed corn plants with healthy ears with many viable seed kernels. Seedlings were transplanted into individual pots filled with soilless substrate and placed onto water-tight benches. The benches were automatically irrigated by being flooded and drained with automatically formulated nutrient-rich water such that each pot received the similar amount of water and fertilizer for optimum growth. Uniformity of irrigation provided for equal timing of all plant milestones, especially pollination and harvest. All unused water was captured and stored for a future watering cycle. The benches will be designed to transport the pots of corn plants that were grouped onto benches within the greenhouse, allowing access to all the plants to more efficiently complete manual labor tasks, such as transplant, crop maintenance, pollination and harvest. The optimum plant growing environment at the UA-CEAC greenhouses was maintained by the greenhouse climate-controlled systems including: heating, cooling, shading, lighting and pest control. Many crop cycles have been completed substantiating the consistency of the successful procedures. As a result, the company has invested in the design and construction of a 7-acre [2.7 hectare] seed corn production facility, including a 87,000 square foot [8000 square meter] processing lab and office facility, will begin operations in November 2018 in Marana, Arizona
- A 24 x 30 greenhouse and recirculating nutrient delivery system is near completion for the roof top of the Student Union Memorial Center (SUMC) to produce fruiting crops for delivery to the Student Pantry for all food insecure UA students. Established by Center Director Todd Millay, the facility will be managed by CEAC personnel in conjunction with student employees. CEAC has supported and helped design the facility. Industry support through hardware donations and financial assistance has been provided by AutoGrow, Grodan and PolyTex Greenhouse Co.

- The UA-CEAC recently established vertical farm-based research, education, extension and outreach facility (UAg Farm). Efforts are ongoing with multi-tier based growing beds, LED lighting and environmental monitoring and controls to establish a propagation chamber to grow transplants for the research in UAg Farm facility.
- An LED lighting system (Red, Blue, White) was installed in a 300 m^2 mushroom research greenhouse. The effect of light quality and intensity along with substrate compositions are being evaluated on yield, nutritional content and bio-efficiency in the production (Barry Pryor, PI).

2. Unique Plant Responses

3. Accomplishment Summaries

- Kacira, in collaboration with Grafted Growers LLC., completed a USDA-SBIR Phase II project. CFD based modeling evaluated various air flow distribution systems and proposed a design that improved air flow uniformity and environment in transplant production beds for multi-tier based vertical farm system. The proposed design is being implemented by the company in their scaled-up production system.
- In 2017, six, 5-day Intensive Grower crop specific courses (116 attendees @ 40 hours each); and one, 6-day General Greenhouse course (65 attendees @ 32 hours each); total of 181 attendees in 7 courses for 6720 contact-hours. Intensive courses offered by Myles Lewis (Lettuce) and Stacy Tollefson (Tomato) with organizational help by Gene Giacomelli and program coordinator Austin Smith.
- Annual CEAC Research Retreat, 25 students, 6 faculty, 3 staff and CEA enthusiast and friends presented introduction to their current CEA activities, August 11-2017, moderated by Kacira and organization support with Austin Smith, CEAC Program Coordinator.
- GHP/GAP Certificate training class, Stewart Jacobson, Food Safety Projects Coordinator, Agricultural Consultation and Training, Arizona Department of Agriculture, June 13, 2017, at the CEAC, 29 attended, organized by Gene Giacomelli.
- UA CEAC organized the 17th Greenhouse Crop Production and Engineering Design Short Course (March 12-16, 2018) with 110 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 with theory and practical use.
- A one-week tomato production intensive course was offered by Dr. Stacy Tollefson to 20 participants in January 2018.
- Two one-week lettuce production intensive course was offered by Myles Lewis of the Arizona Vegetable Company to a total of 30 participants in January and March 2018.
- Cuello has been directing the Arizona Green Box, a modular vertical farming project using a shipping container in which students grow crops hydroponically using artificial lighting. Cuello and his students designed an original cultivation system, the V-Hive Green Box, that is intended to achieve maximum crop productivity per unit volume in a vertical farm facility, is amenable to automation, and for which a provisional patent has been secured by the UA. Sponsored by the UA Green Fund, the Arizona Green Box has been providing educational outreach to students and members of the community to foster awareness of food security and environmental sustainability.
- The *Secure, Sustaining & Sensational CEA Dinner* and 'awareness-raiser' (April 6) was hosted for CEAC stakeholders and the Tucson community to showcase regional gastronomy and the staple

CEA is for securing local food sources. The Carriage House Downtown, Fund-raiser, 130 people attended.

- The *CEA Leadership Forum Southwest* (April 7) brought together CEAC stakeholders for a pre-Advisory Board meeting, to discuss the positioning of CEAC's research, education and extension activities with industry demand, 40 people, CEAC faculty, staff, students, and industry participants attended.
- Presentation to the USDA NIFA Listening Session "NIFA Listens: Investing in Science to Transform Lives", stakeholder meeting November 2,2017, Sacramento, CA. Prepared/Delivered informational documents by Gene Giacomelli.
- Member of EDEN ISS FRR - SAB Scientific Advisory Board for the DLR EDEN-ISS Antarctic project, Daniel Schubert, June 2017 by Gene Giacomelli.
- Gene Giacomelli completed a 6-month Sabbatical visiting California, Florida, New Hampshire, and the Netherlands with focus on the wine grape, strawberry, raspberry and blueberry production capitols of the US.

4. Impact Statements

- Using the controlled environment changed the future in the development of new varieties of field corn for animal feed. Stefanie Boe, Monsanto Company's Community Relations/Site Enablement Lead stated that: "CEAC has been an instrumental partner in developing the necessary technology and capacity to conceive and build our new $100M Marana, Arizona Greenhouse Complex, creating 40 - 60 new local jobs which range from HVAC engineers to plant biologists, and access for others within the company." The Marana facility represents a highly automated greenhouse hydroponic crop production system for the continuous yearly production of seed corn for breeding new varieties. Future benefits to the farmer include new breeding lines, developed up to 3 years faster (7 rather than 10 years), that ultimately create new corn varieties with attributes farmers will need, such as drought or salt tolerance to meet the effects of climate change. Given that the Monsanto Company supplies 70% of the world's feed corn production our science and engineering technology will be affecting billions of dollars of the global agricultural economy. This new system recycles all its irrigation water and nutrients for seed corn production, and it requires only 20% of the total amount that is used in field production. Furthermore, with recycling, there is no discharge to the environment of waste water or plant nutrients. The closed environment of the greenhouse makes IPM [Integrated Pest Management] highly effective for control of pests and diseases, effectively eliminating the need for chemical pesticides.

5. Published Written Works

Books/Book Chapters

Refereed Journal Articles

Montoya, A., M. Kacira, E. Van Henten. 2018. Sensing in controlled environments-based horticulture: A review. European Journal of Horticultural Sciences [In review]

López-Cruz, I., E. Fitz-Rodríguez, R. Salazar-Moreno, A. Rojano-Aguilar and M. Kacira. 2018. Development and analysis of dynamical mathematical models of greenhouse climate: a review. European Journal of Horticultural Sciences [In review]

Refereed Conference Proceedings Articles

Romero, E. J. B., and Kacira, M. 2017. Greenhouse technology for cultivation in arid and semi-arid regions. *ActaHorticulturae*, 1170, 17-30.

Kacira, M., M. Jensen, T. Robie, S. Tollefson, G. Giacomelli. 2017. Use resources wisely: waste management and organic liquid fertilizer use in greenhouse production system. *ActaHorticultrae*, 1164, 541-548.

Furfaro, R., Giacomelli, G., Sadler, P. and Gellenbeck, S., 2017. The Mars-Lunar Greenhouse (M-LGH) Prototype for Bio Regenerative Life Support: Status and Future Efforts. Proceedings of ICES, Paper 347, South Carolina [in press].

Okada, K., I. Yehia, M. Teitel, M. Kacira. 2017. Crop Production and Energy Generation in a Greenhouse Integrated with Semi-transparent Organic Photovoltaics Covering. Acta Horticulturae *[In Review]*

Zhang, Y. and M. Kacira. 2017. Analysis of Environmental Uniformity in a Plant Factory Using CFD Analysis. Acta Horticulturae *[In Review]*

Lewis, M.D., Kacheris, W., Giacomelli, G., Barto, N.H. and Dev, M. 2017. Greenhouse Hydroponic Lettuce Production Within Floating Raft Deep-Water Culture, Poster Presentation, GreenSys2017, Beijing, China.

Other Creative Works

- MOOC organized by Kevin E. Bonine, PhD, Director of Education and Outreach, Biosphere 2, The University of Arizona. https://www.coursera.org/learn/biosphere-science-future.
  Week 8, "Feeding the Future" by Gene Giacomelli includes 6 videos, 1 reading, 1 discussion prompt.
- Professional Video Lecture: Plant Based Controlled Environment Plant System Design, University of Florida, IFAS-CALS, video classroom lecture for Environmental Horticulture and CEA, Dec 6, 2017 by Gene Giacomelli
  https://mediasite.video.ufl.edu/Mediasite/Play/4fed138d9443455cb58de829f18642201d
- Landmark of the Mars-Lunar Greenhouse for BBC science television series, *Expedition New Earth:* The Search for a New Earth. Hosted by Professor Stephen Hawking, Christophe Galfard, and Prof. Danielle George, 89 minutes, BBC-4, Sept 11, 2017. Video interview with Gene Giacomelli.
- Created document "Driven by the Future", a summary of UA-CEAC industry partners and current R&D activities at CEAC, Dec 2016, May 2017 update.

Website and social media

CEAC Website: http://ceac.arizona.edu/
CEAC Facebook: https://www.facebook.com/UA.CEAC

Popular Magazine Articles

Kacira, M., N. Mattson, R. Dickson and R. Lopez. 2018. Urban crop production in vertical farms. Produce Grower Magazine, April 2018.

Pigott, S. 2018. The Future of Farming Takes Root. Interview with Cuello and Kacira. University of Arizona Communications, UA News, March 21st.

Klosterman, S. 2017. CEA is here to stay, ag professors say. Interview with Kacira and Cuello. Vegetable Growers News, December 2017.

Wilson, T. 2018. Vertical Farming. Interview with Kacira and other colleagues from US institutions. Prism Magazine, American Society for Engineering Education, April 2018.

Growing Secure, Sustainable, Sensational Foods at Controlled Environment Agriculture Center, Lee Allen, BizTucson, Vol 9(2):108-109, Summer 2017. Interview with Gene Giacomelli.