NCERA-101 Station Report – Cal Poly Pomona
Reporting Period: May 1, 2024 – April 30, 2025
Submitted by: Dr. Eshwar Ravishankar, eravishankar@cpp.edu

1. New Facilities and Equipment

Dr. Eshwar Ravishankar, Assistant Professor in the Plant Science Department at Cal Poly Pomona, has been actively developing multiple controlled environment systems to advance urban agriculture research and education. The following infrastructure and equipment have been added over the past year:

- **Automated Leafy Greens and Microgreens Container**: A modular growing system is under construction, featuring integrated environmental controls for temperature, humidity, CO_2, and nutrient delivery. The system incorporates Bluelab pH/EC/DO sensors, Hanna GroLine in-line sensors, and Titan Controls CO_2 regulation for real-time monitoring and automation.
- **Mushroom Pod**: A dedicated mushroom cultivation unit has been developed using insulated Gorilla Grow Tents (5' x 9' and 4' x 8') equipped with LED clone lights, environmental sensors (CO_2, humidity), TentX control system, and custom racking to support vertical growing. The setup supports research on indoor fungal crop optimization under varying air quality and moisture regimes.
- **Fluence LED Lighting Systems**: Procured and in the process of installing over 170 Fluence VYPR 3p LED fixtures for use across leafy greens and mushroom facilities. These lights are paired with SHYFT lighting schedulers, wireless dimming modules, and DC Flex cabling to enable advanced spectral manipulation and programmable photoperiod control across cultivation zones.
- **Environmental Control & Support Equipment**: A suite of supporting tools including heat mats with digital controllers, dehumidifiers (Quest Dual 105), RO water systems, air movers, and Can-Fan filter systems have been procured to establish tightly regulated microclimates across research units.
- **Spectroradiometry Tools**: Acquired the Apogee MS-100 handheld photobiology spectroradiometer, enabling high-resolution spectral analysis of lighting conditions (including PPFD, ePPFD, far-red fraction, and CRI). This enhances the lab's capacity to validate and tune light environments for optimized plant responses.
- **Planned Acquisition – Freight Farms Commercial Unit**: A commercial-scale Freight Farms hydroponic container farm is in the procurement process. This facility will serve as a demonstration and research unit for containerized urban agriculture, featuring

complete automation and real-time cloud-based monitoring of plant environment variables.

2. Unique Plant Responses

- The integration of Raspberry Pi-based control systems with Atlas Scientific sensors for pH, EC, temperature, and flow is expected to improve environmental stability and consistency in growth outcomes. This sensor feedback loop will serve as a foundation for predictive automation using machine learning models.
- Trials are testing the hypothesis that automated real-time environmental adjustments—particularly light spectrum manipulation and photoperiod control—will result in measurable improvements in lettuce morphology, including firmer leaves and more intense green pigmentation.

3. Accomplishments

3.A. Short-Term Outcomes

- Integrated Raspberry Pi-based automation with Atlas Scientific sensors for real-time environmental control in hydroponic systems, improving responsiveness and data fidelity in lettuce production trials.
- Developed and internally deployed a web-based decision-support tool for estimating greenhouse energy demand and environmental performance across 25 global climate zones, enabling optimized energy planning and operational benchmarking for CEA systems.
- Engaged CSU system collaborators and private container farm vendors to explore deployment of automated controlled environment systems for urban food production, contributing to regional CEA technology transfer and education.

3.B. Outputs

- Created a web-enabled greenhouse energy modeling platform, combining high-performance simulation results with a trained machine learning model (~97% accuracy) to enable rapid, location-specific analysis of lighting, HVAC, and crop scheduling needs.
- Completed and field-tested a prototype automated NFT system for leafy greens, integrated with Mycodo software and IoT sensors for temperature, humidity, EC, and pH.

- Published a comprehensive setup guide for sensor integration and system calibration for student researchers, currently used in undergraduate coursework and capstone projects.
- Developed a modular mushroom production unit and microgreens container with LED lighting and climate control to support research on non-traditional CEA crops.

3.C. Activities

- Initiated student-driven research on environmental optimization for lettuce in CEA, including experiments on light intensity, EC levels, and photoperiod scheduling.
- Conducted interdisciplinary workshops to cross-train students in embedded systems, plant science, and data logging, using the Raspberry Pi + Mycodo automation stack.
- Collaborated with Freight Farms and campus facilities to plan retrofitting and integration of a commercial shipping container farm for applied research, demonstration, and teaching.

3.D. Milestones

- Full deployment of the machine-learning-supported greenhouse energy web-tool is scheduled for Fall 2025, with planned pilot testing at collaborating institutions.
- Yield trials from the NFT system and mushroom pod will be harvested and analyzed by Summer 2025 to validate sensor-driven optimization hypotheses.
- Integration of real-time environmental control, nutrient dosing, and energy monitoring in all systems (NFT, microgreens, and container farm) is targeted for completion by Winter 2025.

4. Impact Statements

- A web-based greenhouse energy decision-support tool developed at Cal Poly Pomona enables growers and researchers to simulate CEA energy demand across 25 climate zones with 97% model accuracy. This tool reduces simulation time by over 90% compared to traditional models, supporting more sustainable facility design and operation.
- The integration of open-source environmental sensor control (using Raspberry Pi and Mycodo) in hydroponic and microgreen production systems is improving undergraduate student engagement and providing low-cost, scalable CEA automation templates for other institutions and educators.

- Student-led research in automated lettuce production is generating real-time environmental and yield data that will feed machine learning models for future prediction of crop performance under different resource and climate scenarios, laying groundwork for AI-driven smart farming systems.

Grants and Resources:

Extramural Grants

- *Developing Energy and Crop Growth Software Modules for Vertical Farms and Greenhouses*
  Amount: $12,500 (Subaward)
  PI: Ricardo Hernandez, NCSU | Co-PI: Eshwar Ravishankar
  Funding Source: Controlled Environment Agriculture Coalition
  Awarded: 02/16/2024 | Term: 2023–2024

Intramural Grants (Cal Poly Pomona)

- *Innovative Cultivation Solutions through the Development of an Automated Hydroponic System for Vertical Microgreens Farming*
  Amount: $9,900 | PI: Eshwar Ravishankar
  Funding Source: RSCA (Research, Scholarship, and Creative Activities)
  Awarded: 04/12/2024 | Term: 2024–2025
- *Developing a Controlled Environmental Agriculture Facility for Automated Microgreen Production*
  Amount: $5,600 (includes $5,000 student support)
  Funding Source: Office of Undergraduate Research, STARS Program
  Awarded: 05/06/2024 | Term: 2024
- *Cultivating Tomorrow's Workforce: Empowering Undergraduates through Classroom Learning in Precision Farming*
  Amount: $9,585 | PI: Eshwar Ravishankar
  Funding Source: SPICE Grant (Special Project for Improving Classroom Experience)
  Awarded: 04/16/2024 | Term: 2024–2025
- *Running RO Like a Cyclic Engine: Maximizing Water Recovery and Efficiency for Urban Farming*
  Amount: $15,000 | Co-PI: Eshwar Ravishankar
  Funding Source: Strategic Interdisciplinary Research Grant (SIRG)
  Awarded: 05/08/2024 | Term: 2024–2025

- *Mapping Production Strategies for Microgreens in Indoor Vertical Farms*
  Amount: $5,000 (2 students x $2,000 + $1,000 materials)
  Funding Source: Office of Undergraduate Research, RIO Program
  Awarded: 10/11/2023 | Term: 2023–2024