2023 NCERA-101 Station Report from Georgia

State rep: Rhuanito Ferrarezi

Other faculty members: Marc van Iersel (deceased during the reporting period), Andrew Ogden, and Erich Schoeller (both new, hired within the report period)

1. New Facilities and Equipment. We acquired a PPSystems Ciras-4 infrared gas analyzer, Metrohm 916 Ti-touch automatic potentiometric titrator, Konica Minolta CR410 chroma meter, and the CID Biosciences CI-710S leaf spectrometer.

2. Unique Plant Responses. excess light received one day can be 'carried over' to the next, and our study concluded that the DLI requirement for oakleaf lettuce (Lactuca sativa 'Green Salad Bowl' and 'Red Salad Bowl') can be reduced by approximately 5.25 mol·m−2·d−1 on the day following a sunny day.

3. Accomplishments:

3.A. Short-term Outcomes:

Biofeedback: An innovative supplemental light control strategy called the "Chlorophyll fluorescence-based biofeedback system" will benefit growers by reducing electrical energy costs by optimizing lighting intensities according to plants' physiological responses.

Phenotyping: Implementation of sensing technologies to facilitate greenhouse management practices and innovation of decision-making systems based on non-destructive information to anticipate potential losses in yield.

Sap analysis in CEA: Developing a sap extraction method to improve quality and reduce farmer costs. This method will facilitate quicker access to information on CEA fertilization needs and crop deficiencies.

Nutrient management: My research will provide producers in controlled environment agriculture (CEA) with strategies to reduce production inputs such as water and soluble fertilizer while maintaining the optimal yield of leafy greens in hydroponic production. These strategies will reduce production costs for CEA growers and, in turn, for their consumers, which can increase access to nutritious produce in areas lacking arable land. Reducing fertilizer use will also mitigate fertilizer runoff from CEA production facilities, which can adversely impact the water supply in surrounding communities and ecosystems.

Perovskite solar panels on top of greenhouses: Clean energy for greenhouse crop production without deterring crop yield/photosynthetic capacity, based on my chapter one photovoltaic research.

Minimizing calcium tip burn: Utilizing higher downward airflow rates to allow lettuce to reach its maximum yield potential without experiencing the physiological disorder that makes lettuce unmarketable.

3.B. Outputs:

Biofeedback: Research results have been presented 5 times in domestic/international conferences and once as webinars.

Phenotyping: Analytical workflows and tools to extract imaging information that has biological significance for plant research; 2) Establish methodologies to incorporate machine learning in the image processing and analysis of multidimensional data; and 3) Association of multiple sensing technologies, including image and environmental sensors to provide a more profound analysis of crop status.

Sap analysis in CEA: Presented research at ASHS Orlando 2023, Swiss Cleantech Symposium 2023, and SR-ASHS Atlanta 2024. we have identified two methods that align with control, marking a significant advancement in sap extraction research and preparing to publish these findings comprehensively.

Nutrient management: Substantial infrastructure was also installed as part of this research project, including constructing an indoor vertical farm with automated LED lighting, temperature, relative humidity, and carbon dioxide control.

3.C. Activities:

Nutrient management: Oral presentation at the American Society of Horticultural Sciences in 2023 and Organized visits to CEA producers in Georgia and Alabama to understand real challenges producers face.

3.D. Milestones:

Phenotyping: Developed a commercially comparable low-cost multispectral imaging system for horticultural research capable of plant nutrient concentration change detection with customizability to stay at the cutting edge of imaging research.

4. **Impact Statements**.

Light carryover: Our research unveils a groundbreaking approach to greenhouse lighting, leveraging excess sunlight to slash supplemental lighting costs. Through strategic light management, we've achieved remarkable energy savings of up to 30% while preserving crop yields. This innovation promises enhanced profitability and sustainability in greenhouse operations, with potential annual energy savings of 75–190 MWh/ha in lettuce production.

Substrate research: Our research evaluated 13 commercial substrate mixes in a greenhouse DWC system over three seasons, assessing their impact on arugula and lettuce growth, yield, and quality. We found significant variations in plant performance, with peat-based substrates outperforming coir and inorganic options like rockwool. A blend of 75% peat and 25% fine coir produced the best results, yielding superior plant

height, width, and biomass. Seasonal differences were observed, with fall crops showing higher resource use efficiency. Our study emphasizes the need for tailored hydroponic substrates to optimize yield and quality across seasons, contributing to sustainable advancements in controlled environment agriculture.

Calcium and tipburn under different airflows: Our study fills a crucial gap in indoor vertical farming by optimizing airflow rates and nutrient concentrations for lettuce and spinach production. We found that slow airflow rates and a Resh recipe with high calcium concentration significantly increase yields without compromising quality. This insight offers a promising solution to meet rising food demands sustainably, addressing the challenges posed by population growth and urbanization.

5. **Published Written Works**.

Refereed

1) Jayalath, T. C.; van Iersel, M. W.; **Ferrarezi, R. S.** 2024. The energy requirement for supplemental greenhouse lighting can be reduced by considering 'excess' light from the previous day. *Plants* 13(5): 652. DOI: 10.3390/plants13050652
2) **Ferrarezi, R. S.**; Nguyen, L; Poole, S. D.; Housley, M. J.; Qin, K. 2024. Multi-season evaluation of substrates for optimized arugula and lettuce production in hydroponics. *HortScience* 59(3): 403-411. DOI: 10.21273/HORTSCI17606-23
3) **Ferrarezi, R. S.**; Qin, K.; Hazard, C.; Gatard, E.; Gastaldo, T. B.; Housley, M. J.; Nieters, C.; Mesquita, M. 2024. Airflow, fertilizer solution recipes, and calcium concentrations influence lettuce and spinach growth in an indoor vertical farm. *Scientia Horticulturae* 328(112948) 1-11. DOI: 10.1016/j.scienta.2024.112948

Abstracts

1) Maynard, R.; **Ferrarezi, R. S.;** Lombardini, L. 2024. Performance of *Matricaria recutita* and *Petroselinum crispum* varieties in an indoor vertical hydroponic system. *Proceedings.* 2024 Southern Region American Society for Horticultural Science, Atlanta/GA, USA.
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5) Iradukunda, M.; van Iersel, M. W.; Seymour, L.; Lu, G.; **Ferrarezi, R. S.** 2024. Seedling vigor and germination rate of lettuce cultivars were quantified using a simple and

automated imaging technique. *Proceedings.* 2024 Southern Region American Society for Horticultural Science, Atlanta/GA, USA.

6) Volz, T.; Rodrigues, C.; Dunn, L. L.; Jackson-Davis, A.; **Ferrarezi, R. S.** 2024. Bridging the gap: A comprehensive needs assessment survey to identify food safety knowledge gaps among indoor growers in the United States. *Proceedings.* 2024 Southern Region American Society for Horticultural Science, Atlanta/GA, USA.
7) Rodrigues, C.; Volz, T.; Blanchard, C.; Dunn, L. L.; **Ferrarezi, R. S.**; Jackson-Davis, A. 2023. Developing an engaging produce safety add-on training for soilless growing operations. *Proceedings.* 2023 National Food Safety Outreach Program (FSOP) Meeting, Tampa/FL, USA. URL: https://conference.ifas.ufl.edu/fsop/documents/FSOP-2023-Program-Book-Online.pdf.
8) **Ferrarezi, R. S.**; Qin, K.; Hazard, C.; Gatard, E.; Gastaldo, T. B.; Housley, M. J.; Nieters, C. E.; Mesquita, M. 2023. Airflow, fertilizer solution recipes, and calcium concentrations influence lettuce and spinach growth in an indoor vertical farm. *HortScience* 58(9): S224 (Abstr.). 2023 ASHS Annual Conference, Orlando/FL, USA.
9) Hirst, A. K.; Anee, S. A.; Huber, A. C.; Housley, M. J.; Nieters, C. E.; Qin, K.; **Ferrarezi, R. S.** 2023. Beneficial microbes alleviate osmotic stress in lettuce and not pak choi in hydroponics. *HortScience* 58(9): S225 (Abstr.). 2023 ASHS Annual Conference, Orlando/FL, USA.
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21) Nam, S.; van Iersel, M. W.; **Ferrarezi, R. S.** 2023. A chlorophyll fluorescence-based biofeedback system to optimize LED lighting: From seedling to harvest stage. *Proceedings* OS03-06: 102. 2023 GreenSys International Symposium, Cancun/Quintana Roo, Mexico.
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