2025 Annual Report
NCERA-101 Controlled Environment Technology and Use

Project Number: NCERA-101
Project Title: Controlled Environment Technology and Use
Period Covered: 04-2024 to 04-2025
Date of This Report: May 30, 2025

2025 NCERA-101 Annual Meeting
April 5 to 9, 2025 in Monterrey, Mexico
Hosted by: Leo Lobato (Karma Verde Fresh)

PARTICIPANTS

NCERA-101 Participants List 2025 Annual Meeting

Last name	First name	Institution
Ahamed	MD Shamim	UC Davis
Alvarado	Daniela	UAAAN, Mexico
Armstrong	Sarah	Univ Queensland, Australia
Baker	Christian	Utah State University
Baldwin	Michael R	University of Wyoming
Blonquist	Mark	Apogee Instruments
Both	AJ	Rutgers University
Breyer	Roberto	Biora/Minearc
Bugbee	Bruce	Utah State University
Burns	Andrew	Univ of Guelph, Canada
Cantu	Josué	Innovation Farms, Mexico
Carrasco	Gilda	Talco, Chile
Chen	JJ	University of Wyoming
Dsouza	Ajwal	Univ of Guelph, Canada
Eckels	Madigan	Utah State University
Ertle	John	PP Systems
Eylands	Nathan	University of Minnesota
Feng	Iris	North Dakota State University
Forystek	Ava	Cornell University
Friedrich	Jacob	University of Tennessee
Friesen	Patrick	Biochambers
Hammad	Ahmed S H	Conviron
Hernandez	Riccardo	NCSU
Hollick	Jason	Ohio State University
Imberti	David	Percival Scientific

Last name	First name	Institution
Imberti	Henri	Percival Scientific
Juan	Tagino	Karmaverdefresh
Kanwar	Rameshwar	Iowa State University
Langenfeld	Noah J	Utah State University
Levine	Christopher	University of Tokyo
Lim	Sungeun	Purdue University
Ling	Peter	Ohio State University
Linzer	Stefanie	Valoya
Lobato	Leo	Karmaverdefresh
Mattia	Samuel	Cal Poly Pomona
Mattson	Neil	Cornell University
Mitchell	Cary A	Purdue University
Nguyen	Jacqueline	Univ of Guelph, Canada
Oosterom	EJ van	Univ Queensland, Australia
Pace	Abby	Cornell University
Rivas	Bruno	Biochambers
Romer	Mark	McGill University
Ruiz	Sofia	NCSU
Runkle	Erik	Michigan State University
Saravitz	Carole	NCSU
Scheel	Carlos	TEC Monterrey, Mexico
Shultz	Richard	Santa Fe Community College
Timmons	Brett	NCSU
Topete	Mercedes Arias	Puerto Vivo Urban Farm, MX
Tran	Adele (Dung)	Koidra
Tran	Kenneth	Koidra
Tripathi	Pooja	Ohio State University
Ugur	Senay	University of Idaho
Valdez	Luis Alonso	UAAAN, Mexico
Velasco	Vera M	Univ of Toronto Mississauga
Villouta	Camilo	University of Rhode Island
Wang	Liping	University of Wyoming
Willson	Graham	Conviron
Xia	Jiaqi (Darren)	Ohio State University
Yelton	Melanie	Growbig
Ying	Qinglu	University of Kentucky
Yoder	Graydon	Cornell University
Zhang	Ying	University of Florida
Zheng	Youbin	Univ of Guelph, Canada

SUMMARY OF MINUTES OF ANNUAL MEETING

NCERA-101 Business Meeting Summary 2025 Annual Meeting
Chair: Dr. Neil Mattson
Meeting notes: recorded by Dr. Ricardo Hernandez and compiled by Dr. Qingwu Meng
Meeting started at 9:23 AM on April 6, 2025.

- Introduction and Welcoming Remarks from meeting host (Leo Lobato)
- Introduction of the NCERA-101 Executive Officers (Neil Mattson)
    - Chair: Dr. Neil Matson (Cornell University)
    - Chair Elect: Dr. Celina Gómez (Purdue University)
    - Secretary: Dr. Qingwu Meng (University of Delaware)
- Recognition of Industry Sponsors (Leo Lobato, Neil Mattson)
- Approval of Minutes from 2024 (Celina Gomez)
    - Motion to approve by Bruce Bugbee, seconded by Nathan Eylands. Motion approved unanimously.
- Announcements of Other Relevant Conferences (All)
    - 2025 OHCEAC Annual Conference, Columbus, OH, July 16 (https://ohceac.osu.edu/ohceac_annual_conference)
    - 2025 ASHS, New Orleans, LA, July 28-August 1 (https://ashs.org/)
    - 2025 CEAg World Conference & Expo, Durham, NC, Nov. 19-21 (https://www.ceagworld.com/events/)
    - 2025 ISHS GreenSys, Almeria, Spain, June 22-27 (http://www2.ual.es/greensys2025/)
    - Shamim noted the 2025 American Society for Engineering Education annual conference, Montreal, Canada, June 22-25 (https://www.asee.org/events/conferences-and-meetings/2025-annual-conference-exposition)
- Administrative Advisor's Report (Ramesh Kanwar)
    - Congratulations on the committee's 50th anniversary, and on receiving the 2024 Excellence in Multistate Research Award
    - Appreciation for the NCERA 101 Executive Committee for excellent committee work and Leo Lobato and his team for being a wonderful host.
    - Project will end on September 30, 2026, so the renewable request will be due on Dec. 15, 2025.
    - Election of office-bearers of the NCERA 101 Committee
    - Planning for next year's meeting in England
    - Annual report of the committee will be due on June 8, 2025, and submitted on the NIMSS website.
    - Highly encourage agInnovation North Central 2025 Award
    - Innovate Newsletter
        - Early career award – Assistant Professor rank only
        - Mid-career award – Assoc. Prof. < 10 years after promotion
        - Deadline for nominations: March 30, 2026
- Membership Report (Mark Romer)

- 1969 ASHS Working Group on Growth Chambers and Controlled Environments → 1976 NCR-101 Committee on CE Technology and Use → 2006 NCERA-101
- 7th International CE Meeting, Edinburgh & Dundee Scotland, September 6-9, 2026
- 30+ years of membership: Cary Mitchell, Ray Wheeler, Bruce Bugbee, Mark Romer, Gary Stutte, A.J. Both, Henry Imberti

NCERA-101 Membership Summary, March 2025
Mark Romer, *Membership Secretary*

Membership Number	**March 2024**	**March 2025**
	188	195
	Additions: 12; Deletions: 5; Net Gain: 7	
Membership Composition	**Institutions**	**Members**
Phytotrons & Controlled Environment Facilities	9	12
University Departments, Agr. Exp. Stations	74	97
Government Organizations & Contractors	11	14
Industry Representatives	57	72
Total Number of Institutions / Members	**151**	**195**
Total Number of Countries	8 (+0)	
Total Number of US States	40 (+3)	

New Institutions

- BFG Supply Company
- Systemic Sensing LLC
- Resource Innovation Institute
- Light4Food
- Cal Poly Pomona
  - Plant Science Department
- University of Wyoming
  - Dept of Civil and Architectural Engineering
- University of Rhode Island
  - Dept of Plant Sciences and Entomology
- North Dakota State University
  - Dept of Agricultural and Biosystems Engineering
- University of Kentucky
  - Department of Horticulture

- Graduate Student Lightning Talk/Travel Grant Summary (Ricardo Hernandez)
  - 15 awarded students from 8 different universities, with $1000 per student provided to the universities.
  - We also have posters featuring research from all the presenting students.
  - There is a “lightning talk competition” that evaluates students’ presentations.
  - Top 3 students will be recognized (no cash prize): Students will be announced at the dinner.
- Website Report (Carole Saravitz)

    - The NCERA-101 website traffic analytics were shared, showing the home page and the meetings page had the most views, and most views were from the U.S., followed by Canada, Australia, China, and India among 91 total countries.
- Financial Report (Bruce Bugbee)
    - NCERA-101 Travel Fund: $39,502 - $15,000* = $24,502
        - * Student Travel Awards for 2025 meeting
    - Marc van Iersel Travel Fund: $15,438
- Guidelines
    - ASABE Standards efforts (Shamim Ahamed)
        - ES-311 - S640 - Definition of Metrics of Radiation for Plant Growth. (Controlled Environment Horticulture) Applications. Published. Will be Renewed. New committee created to modify and include ePAR and other definitions.
        - ES-311 - S642 Recommended Methods of Measurements and Testing for LED. Radiation Products for Plant Growth and Development. Published, undergoing a review and will need an update when S640 is updated.
        - ES-311 - X644 Performance Criteria for Optical Radiation Devices and Systems Installed for Plant Growth and Development. The initial ballot is completed and being reviewed; the second ballot should be available shortly
        - Air Quality in Buildings and Facilities Utilized for the Cultivation, Production and Processing of Cannabis, Review deadline 2024-04-24.
        - PAFS - 30 - X653 Recommended Practice for Heating, Ventilation and Air Conditioning (HVAC), and Lighting Systems Used for Indoor Plant Growth without Sunlight. Published ANSI/ASABE/ASHRAE EP 653.
        - ASABE PASF-30 and ASHRAE Committee for HVACD standard for Greenhouses.
        - ASABE EP566.2 JUN2012 (R2022) Guidelines for Selection of Energy-Efficient Agricultural Ventilation Fans.
        - ASABE S565 OCT2005 (R2020) Agricultural Ventilation Constant Speed Fan Test Standard.
        - X669 Agrivoltaics Standard: ASABE and the Solar Energy Industries Association (SEIA).
        - Other standards of interest: ANSI/UL 8800-2023 Standard for Safety for Horticultural Lighting and Equipment and Systems, which is a revision of ANSI/UL 8800-2021.
    - Controlled environment research data sharing task force (Neil Mattson)
        - Highlighted rationale, importance, and methods of sharing data via the Controlled Environment Agriculture Open Data Project (CEAOD) (https://ceaod.github.io/)
- Future Meetings:
    - 2026 – CEUG International Meeting, Edinburgh and Dundee, Scotland, September 6-9, 2026, organized by the Committee of the UK Controlled Environment Users' Group. Locations: University of Edinburgh and James Hutton Institute. A schedule at a glance was shared (registration on September 6, meetings on September 7-8, tours on September 9). A support committee

consisting of Jonathan Frantz, Qingwu Meng, Mark Romer, and Melanie Yelton. was proposed to discuss topics on potential speakers from NCERA-101, graduate student poster competition, and travel support. Volunteers included Celina Gomez (nominated by Mark Romer), Nathan Eylands (self-nominated), and Leo Lobato (self-nominated).
    - 2027 – NCERA-101 meeting at the University of Georgia (Rhuanito Ferrarezi). Rhuanito presented a video proposing Athens, GA as the host site. Motion to approve UGA by Mark Romer, seconded by Youbin Zheng (University of Guelph), passed unanimously.
- Election of New Secretary
    - Marc Blonquist (Apogee) was nominated by the Executive Committee.
    - Motion to approve by Melanie Yelton, seconded by Henry (Percival).
    - No opposition: nomination approved.
- New Business Open Discussion
    - Survey results/discussion – optimal month/timing for future NCERA-101 meetings
    - Renewal NCERA-101, 5-year project terms on 9/30/2026
        - Committee to work on renewal proposal (due in NIMSS by 12/1/2025), which will include 1) issues and justifications; 2) objectives; and 3) project participants.
        - Committee volunteers include Melanie Yelton, Dr. Vera M. Velasco (University of Toronto), MD Shamim Ahamed (UC Davis), and Erik Runkle (nominated by Mark Romer).
        - Deadlines:
            - 9/15: Request to Write a Proposal
            - 10/15: Final project Objectives due in NIMSS
            - 12/1: Full proposal due in NIMSS. This deadline is FIRM
    - Funding to support travel to 2026 CEUG International Meeting in Scotland
    - A committee including Melanie Yelton, Jonathan Frantz, Qingwu Meng, and Mark Romer will meet online to discuss.
- Passing of the Gavel
    - Chair transition from Neil Mattson to Celina Gomez (incoming Chair)
    - Celina Gomez is the new Chair

Meeting adjourned at 10:47 AM on April 6, 2025.

ACCOMPLISHMENTS

Below are summaries highlighting multistate and external collaborations and linkages. The complete station reports are available on the NCERA-101 website: https://www.controlledenvironments.org/station-reports/

1. New facilities and equipment

Several stations have enhanced their controlled environment agriculture (CEA) capabilities, often with equipment and systems that facilitate collaborative research.

- **North Dakota State University (NDSU)** established two new CEA laboratory spaces within their pilot plant, featuring LED-lit growing racks with environmental monitoring. They also procured a Conviron growth chamber with advanced environmental controls and ordered NFT hydroponic systems and a fertroller from CropKing for nutrient management studies. These enhanced facilities can support collaborative projects focused on optimizing CEA for various crops and environmental conditions.
- **The Ohio State University**'s new Controlled Environment Agriculture Research Complex (CEARC) installed a dry fog humidification system in a 5,000 sqft compartment (AKIMist, Ikeuchi USA). They also acquired a tomato grafting robot (Robo-GRF, Kusakabe, Japan). These advanced systems can be leveraged in multistate projects examining environmental control and automation in protected agriculture.
- The **University of Wyoming Plant Growth & Phenotyping Facility** finalized the deployment of "oQulus" in June 2025. This plant phenotyping project, led by **PhotosynQ Inc.**, a company serving both private and research sectors, features a camera platform on a movable gantry system. It will enable multimodal imaging of plant photosynthetic efficiency, morphology, and response to environmental variation. The system integrates PAM fluorescence, RGB, 3D, and thermal cameras, along with analysis software. Collaborating with the **Wyoming Data Hub** and the **University of Wyoming School of Computing**, the facility will allow researchers on and off campus to utilize the collected datasets, demonstrating a strong linkage between university research infrastructure and external partners.
- The **University of Minnesota** completed approximately 50% of a re-lighting project at their Plant Growth Facility, replacing high-pressure sodium lamps with LED lamps (Fluence Bioengineering, Austin, TX). They also purchased 17 new growth chambers (Conviron, Winnipeg, Canada). The Eylands CEA lab acquired various sensors and a chlorophyll fluorometer, and repaired an infra-gas analyzer. These upgrades enhance the University's capacity for collaborative research in plant lighting, environmental control, and physiological measurements.
- **Cal Poly Pomona** is constructing an automated leafy greens and microgreens container with integrated environmental controls and sensors from Bluelab and Hanna GroLine, along with CO_2 regulation from Titan Controls. They also developed a dedicated mushroom cultivation unit using Gorilla Grow Tents with LED lighting and environmental controls managed by a TentX system. Over 170 Fluence VYPR 3p LED fixtures are being installed across these facilities, paired with SHYFT lighting schedulers. They also acquired spectroradiometry tools (Apogee MS-100). Furthermore, they are in the process of procuring a commercial-scale Freight Farms hydroponic container farm for urban agriculture research and demonstration. These diverse and advanced systems provide opportunities for collaboration on optimizing controlled environment production for various crops.
- The **University of Florida** designed an IoT system for data-driven climate control in greenhouses through a USDA SAS project (PI: Brandon Higgins, **Auburn University**). This system integrates sensors, Wi-Fi communication using MQTT, edge computing via Raspberry Pi, AWS cloud services, and a Grafana dashboard for real-time visualization. This collaborative effort between universities and leveraging cloud technology offers a model for multistate projects focused on intelligent greenhouse management.

- **Auburn University** increased its CEA capacity by adding three new container farms from AmplifiedAg. Two will support on-campus food production and student training (FoodU program), while a third will be used for propagation trials. They are also planning to convert a Freight Farms container into a growth chamber. This expansion, with a focus on student training and potential for propagation research, could link with other institutions involved in similar initiatives.
- The **University of Guelph Controlled Environment Systems Research Facility** designed and built small multispectral LED grow boxes, acquired a 3D printer, and updated their gas analyzers. These in-house developments and upgrades support advanced research in plant responses to light and atmospheric conditions.
- The **University of California, Davis**'s Controlled Environment Engineering (CEE) Lab acquired various environmental sensors and data loggers, enhancing their capacity for monitoring and controlling experimental environments, which is crucial for collaborative research projects requiring precise environmental data.

In summary, several institutions have made significant investments in new facilities and equipment for controlled environment agriculture. Notably, the **University of Wyoming**'s phenotyping project with **PhotosynQ Inc.** and the **University of Florida**'s IoT system developed in collaboration with **Auburn University** highlight direct linkages with external entities and other universities. The advancements across these stations, including sophisticated environmental controls, LED lighting systems, and advanced monitoring tools, provide a strong foundation for future multistate collaborative research focused on optimizing plant growth and production in controlled environments.

2. Unique plant responses

Research across several stations highlighted unique plant responses to various environmental conditions and treatments, often with implications for broader agricultural practices and collaborations.

- **The Ohio State University**, as part of a multistate collaboration led by **North Carolina State University**, investigated artificial chilling to improve strawberry propagation of 'Albion' and 'Fronteras'. They found 'Albion' responded positively, while 'Fronteras' did not, suggesting genotype-specific responses. Additionally, they examined supplemental far-red (FR) lighting to prevent semi-dormancy in short-day strawberry cultivars, observing increased petiole and peduncle length, improved yield and quality, and higher soluble solid concentration with FR treatment. Weekly flower mapping was also used to predict future yields in 'Albion' strawberries, a tool with potential for broader application among US greenhouse growers. Furthermore, their research confirmed that far-red light contributes to photosynthesis in shaded leaves, impacting the understanding of leaf light compensation points. These findings on strawberry propagation and lighting have direct relevance to the controlled environment agriculture industry and could inform collaborative research on optimizing production practices across different regions.
- The **University of Wyoming** reported varied photosynthetic efficiency responses in two pepper varieties ('ACE' and 'Cornito Giallo') to different light spectra, suggesting opportunities for spectral optimization in CEA. They also found that peat-based media

led to higher lettuce productivity compared to calcined clay, relevant for space crop management and sustainable production, potentially linking with NASA or other space agriculture research programs. Transgenic pine tree genes showed functional conservation in Arabidopsis, a finding relevant to understanding long lifespan traits in trees, which could interest forestry research groups. A computer vision pipeline was developed to assess leaf hydration in cotton under drought, demonstrating the application of AI in phenotyping and potentially useful for collaborations focused on water stress in agriculture.

- The **University of Hawaii at Manoa** compared red and blue LED lighting on 'Koba' green onion growth in a hydroponic system, finding that red LED light enhanced growth. This research contributes to the understanding of optimal lighting for specific crops in CEA and could be relevant to other institutions studying lighting effects.
- Researchers at the **University of Minnesota** developed computational models for lettuce in a greenhouse with silicon nanocrystal quantum dots (Si-NC QD), predicting impacts on biomass accumulation based on spectral changes and transmissivity. This interdisciplinary work between horticulture and mechanical engineering demonstrates a collaborative approach to optimizing greenhouse environments.
- The **University of Delaware** investigated the effect of nighttime photoperiodic lighting with warm-white (WW) or red + far-red (R+FR) LEDs on flowering of long-day plants. They found different light qualities were more effective for petunia (WW) and snapdragon (R+FR), providing valuable information for floriculture lighting strategies in controlled environments.
- **Cal Poly Pomona** is integrating Raspberry Pi-based control systems with sensors, aiming for predictive automation using machine learning, which could be a model for collaborative projects focused on smart agriculture technologies. Their trials on light spectrum and photoperiod manipulation in lettuce to improve morphology also contribute to the understanding of plant responses to tailored environments.
- The **University of Wyoming** quantified the relationship between controlled-release fertilizers and native edible berry growth, suggesting potential for reduced fertilizer inputs. They also studied sensor-based irrigation and harvesting on lettuce in a space-farming substrate, finding improved productivity and palatability, relevant to controlled environment and space agriculture. Additionally, they explored the use of terrestrial algae to enhance nitrogen availability for lettuce growth in simulated lunar regolith, a unique contribution to the field of extraterrestrial agriculture.
- Researchers at the **University of Queensland, Australia** compared the growth and development of temperate and tropical species under different light spectra (Fluence VYPR, Heliospectra, natural light) in their new controlled environment facilities. They observed notable responses in sorghum and barley, highlighting the importance of species-specific environmental optimization in CEA. This work provides a basis for international collaboration on understanding plant responses across diverse environments.
- The **University of Georgia** reported numerous unique plant responses in lettuce, petunia, wheat, and rice related to light intensity, nutrient uptake, and stress. These included lettuce adapting to fluctuating light, differential photosynthetic efficiency, morphological changes in petunia with fertilizer and pH, and the impact of light and temperature on wheat and rice. They also investigated the use of imaging systems for plant analysis, the role of microbes in nutrient availability and stress alleviation, and the effects of growth

regulators. Their broad range of studies offers many avenues for collaborative research on optimizing plant growth and resource use in CEA.

- **Cornell University** found that far-red light and daily light integral both impacted petunia quality and flowering, with increased FR hastening flowering, particularly under low DLI. This research contributes to the growing body of knowledge on spectral effects on plant development.
- **Universidad Autónoma Agraria Antonio Narro (México)** observed that silicon application improved strawberry fruit quality, near-zero green light with glutamate might alleviate lightning stress in strawberry, and light quality and salinity stress influenced anticancer alkaloid production in vinca. These findings open possibilities for collaboration on plant stress responses and bioactive compound production.
- The **University of Idaho** is adapting a micropropagation protocol for a rare native plant, *Mirabilis macfarlanei*, for other North American *Mirabilis* species, addressing the need for efficient propagation of native flora for conservation, potentially linking with ecological restoration or native plant nurseries.
- **Auburn University**'s split-root system trials revealed preferential root growth of red kale and tomato to different nutrient/salinity conditions, suggesting species-specific root physiology. Their poultryponics system research showed complex interactions between supplemented nutrients and plant growth, highlighting the need for careful nutrient management when using alternative water sources. These findings could be valuable for collaborations focused on nutrient uptake and alternative hydroponic solutions.
- The **North Carolina State University Phytotron** observed unusual leaf symptoms in cotton, sensitivity to water and fertilizer in corn, and successfully integrated UV-C light for powdery mildew control in strawberry. These practical observations and solutions are relevant to the operational management of controlled environment facilities and could be shared with other phytotron or greenhouse operators.

In summary, the research highlighted across these stations demonstrates a wide array of unique plant responses to environmental factors, nutrient treatments, and genetic variations. Several projects, such as the strawberry chilling study (**Ohio State** and **North Carolina State**), the lettuce modeling (**Minnesota**), and the space farming research (**Wyoming**), inherently involve or have strong potential for multistate or external collaboration. The findings contribute valuable insights to optimizing controlled environment agriculture for various crops and conditions.

3. Accomplishments

3.A. Short-term outcomes

Several stations reported short-term outcomes with implications for controlled environment agriculture practices and potential collaborations.

- **Rutgers University** conducted hydroponic lettuce trials in collaboration with a USDA-funded multi-institutional project (ADVANCEA) to evaluate the impact of air movement on tipburn. This collaborative effort directly addresses a common challenge in hydroponic production.

- The **University of Minnesota**'s Regional Sustainable Development Partnerships program subsidized deep winter greenhouse adoption for Minnesota growers, with input from a UMN CEA professor. This outreach demonstrates a direct link between university expertise and local agricultural development. Additionally, their research on NFT hydroponic systems for basil, involving faculty and students from different departments, found that channel length did not affect yield or nutrient concentration, providing practical guidance for hydroponic system design.
- The **University of Delaware** disseminated research on a chemical biostimulant for tipburn control in hydroponic lettuce, leading to inquiries from growers across the U.S. This immediate adoption of research findings highlights a strong link between university research and the agricultural industry.
- **Cal Poly Pomona** integrated Raspberry Pi-based automation with Atlas Scientific sensors for real-time environmental control in hydroponics, improving lettuce production trials. They also developed a web-based tool for estimating greenhouse energy demand across global climate zones, which could be valuable for benchmarking and collaborative projects focused on energy efficiency in CEA. Furthermore, they engaged CSU system collaborators and private container farm vendors to explore automated CEA for urban food production, fostering regional technology transfer.
- The **University of Georgia** reported several short-term outcomes with publications, providing immediate recommendations for energy-efficient lighting in lettuce, optimal light intensity for photosynthetic efficiency, validation of a low-cost imaging system for phenotyping, and quantified lettuce responses to varying light intensities. They also developed a cost-effective imaging system for canopy analysis and a model for nitrogen uptake in hydroponic lettuce, contributing tools and knowledge applicable across research and commercial settings. Additionally, they examined light and temperature effects on wheat and rice, and the response of hydroponic lettuce to potassium and adaptive lighting. Research on GA3 effects on salt-stressed lettuce seeds and imaging for seed aging and vigor offer new methodologies for stress management and seed quality assessment. Their work on beneficial microbes alleviating salinity stress provides immediate solutions for challenging environments. These diverse outcomes offer numerous points for potential collaboration.
- The **University of Talca, Chile** will inaugurate a vertical horticultural farming module in a recycled container in 2025, aiming to promote technological development for growers, demonstrating international advancements in CEA.
- **Cornell University**'s study on using fish biosolids as a natural fertilizer for organic tomato seedlings showed promising results, with high concentrations performing as well as inorganic fertilizer. This research, utilizing waste from a NYS aquaculture producer, offers a sustainable alternative for organic farming and links agricultural and aquaculture sectors.
- **Universidad Autónoma Agraria Antonio Narro (México)** is contacting farmers to develop technology for accelerating *Vitis* propagation, directly impacting the local viticulture industry. Their measurement of tomato and bell pepper seedling production in vertical farms indicated improved quality and reduced time with optimized lighting.
- The **University of Florida**, in collaboration with **Auburn University**, developed a preliminary tomato phenology model for growth and yield prediction, using greenhouse

data from both institutions for evaluation. This multistate collaboration produced a tool with potential for greenhouse climate control and tomato management optimization.
- The **University of Idaho** successfully introduced and multiplied several *Mirabilis* taxa in tissue culture, with some species successfully rooted and established in the greenhouse, contributing to the propagation of native flora for conservation.
- **Auburn University** continued operating a poultryponics system, demonstrating the potential of poultry processing wastewater for vegetable production with minimal food safety risks, offering a novel waste management and water source solution. Their salinity tolerance trials using a split-root technique showed comparable yields in leafy greens and enhanced quality in tomatoes. They also developed a predictive model for salt stress tolerance in kale grown in aquaponics. Furthermore, they found that root removal in lettuce did not reduce shelf life when stored properly, addressing food safety concerns. Their comparison of energy management techniques in identical greenhouses highlighted the impact of low-energy approaches on yield and quality.
- The **North Carolina State University Phytotron** updated their RO filter system for irrigation and is replacing problematic LED lights with a new system integrated with their environmental controls, improving the operational efficiency of their research facilities.

These short-term outcomes demonstrate practical advancements in CEA technologies, nutrient management, lighting strategies, and sustainable practices, often with clear pathways for adoption by growers and opportunities for further collaborative research.

3.B. Outputs

The research conducted by this multistate group resulted in various outputs, including publications, new technologies, and outreach activities, often involving collaborations across institutions and with external partners.

- **Rutgers University** collaborated with **Cornell University** on a peer-reviewed publication concerning the life cycle assessment and techno-economic analysis of plant factories, demonstrating a direct multistate research output.
- **Percival Scientific** designed a marine LED tile with specific wavelength bands for various marine organisms and developed new controlled environment chambers for pollen. Their PetriClear® LED technology received a patent and an ASABE AE50 Outstanding Innovations award, showcasing industry-relevant innovation.
- **The Ohio State University**'s research on leaf pruning methods in greenhouses led to a more efficient approach, reducing labor input, a practical outcome for the greenhouse industry.
- **The University of Minnesota** published a peer-reviewed article with collaborators on computational models predicting lettuce growth using luminescent solar concentrators, with supplementary data made publicly available. They also submitted papers on plasma-activated water (PAW), including a literature review and a survey of CEA growers' interest in PAW, indicating engagement with the grower community.
- The **University of Delaware** published two peer-reviewed articles in HortScience based on floriculture lighting studies funded by the **American Floral Endowment (AFE)**,

highlighting a linkage with industry funding. They also collaborated with **Arizona State University** on a HortScience publication regarding potassium sulfate supplementation in hydroponic strawberries and with **Croda, Inc.** on a grower-oriented article in *Inside Grower* about tipburn control in lettuce, effectively disseminating research to both academic and industry audiences.

- **Cal Poly Pomona** created a web-enabled greenhouse energy modeling platform using machine learning for location-specific analysis, a tool with broad applicability. They also field-tested a prototype automated NFT system and published a sensor integration guide for student researchers, contributing to education and technology development. Additionally, they developed modular growth units for non-traditional CEA crops.
- The **University of Wyoming**'s collaborative project with the **East Shoshone Community group** on fertilizer management for specialty crops was published in HortScience, demonstrating engagement with local communities. They also collaborated with **Utah State University** on a NASA research grant focused on lunar regolith agriculture, a multistate and federal agency-linked effort. Furthermore, they collaborated with community colleges across Wyoming on an NSF REU program (PI: Liping Wang) for multidisciplinary CEA education, showcasing broader educational impact.
- The **University of Georgia** produced numerous publications in peer-reviewed journals (Frontiers in Plant Sciences, Agronomy, Horticulturae, HortScience, Agriculture, Sensors, HortTechnology, J. Insect Sci., Biol. Control) covering topics such as lighting optimization, nutrient management, imaging technologies, and pest control in CEA. One publication in J. Insect Sci. and another in Biol. Control highlighted work on biological control agents, with one being commercialized in Europe and the U.S., indicating industry impact.
- The **University of Talca, Chile** built a vertical horticultural farming module and is hosting an International Vertical Farming Seminar for researchers, industry, and growers, fostering international knowledge exchange.
- **Cornell University** reported significant outreach, including 6 published academic articles and 5 extension publications. They conducted numerous in-state workshops, presentations, and tours, reaching a large number of participants, and trained students in aquaponics/hydroponics research and outreach. Their out-of-state presentations further extended their impact. They also co-organized a Short-Course on recirculating aquaculture, hydroponics, and aquaponics and partnered in the GLASE consortium's Vivid Canopy initiative to engage women and underserved groups in the agricultural workforce.
- **Universidad Autónoma Agraria Antonio Narro (México)** published a paper in HortScience on calcium nutrition for indoor strawberries and a bachelor's thesis on silicon applications in strawberries, contributing to scientific literature and student training.
- The **University of Florida** developed the main components for a greenhouse-hydroponic tomato model as open-source Python code, making their research accessible for broader use in crop modeling.
- The **University of Idaho** submitted the final report for their *Mirabilis* study, and plantlets from tissue culture were successfully transferred to native planting sites, demonstrating a direct conservation outcome.

- **Auburn University** published several peer-reviewed manuscripts and presented at conferences on topics including aquaponics, poultryponics, salinity tolerance, postharvest quality, and food safety in CEA. They also conducted extension trainings on food safety, indicating both research dissemination and outreach efforts.

In summary, the outputs from this multistate group are diverse, including peer-reviewed publications, development of new technologies and tools, and significant outreach and educational activities. Many of these outputs resulted from collaborations across institutions, with industry partners, and with community groups, demonstrating the strong linkages emphasized in the guidelines.

3.C. Activities

Research activities across the multistate group demonstrate significant collaboration and focus on advancing controlled environment agriculture.

- **Rutgers University** is collaborating with **Cornell University** (GLASE Consortium) on testing horticultural lighting and assessing the environmental impacts of switching to LED lighting. They are also part of the multi-institutional ADVANCEA project, working on hydroponic lettuce production. Additionally, they are collaborating with regional and national partners on agrivoltaic systems research.
- **The Ohio State University** organized the annual OHCEAC CEA Conference, bringing together academic and industry experts. Through the ADVANCEA project, in collaboration with **Rutgers University** and the **University of Arizona**, they offered an online professional course on greenhouse environmental control.
- The **University of Delaware**, **Arizona State University**, and **Colorado State University** continued their collaboration on a USDA NIFA grant focused on tailoring hydroponic factors for emerging food crops. The University of Delaware also engaged with the international agrochemical industry, promoting potential cross-disciplinary collaborations.
- **Cal Poly Pomona** initiated student research on environmental optimization in lettuce CEA and conducted interdisciplinary workshops involving embedded systems, plant science, and data logging. They are also collaborating with **Freight Farms** and campus facilities to integrate a commercial container farm for research and teaching.
- The **University of Wyoming** collaborated with the **East Shoshone Community group** on sustainable methods for growing culturally significant plants. They are also collaborating with **Utah State University** on a NASA research grant for lunar regolith agriculture. Furthermore, they are working with community colleges across Wyoming on an NSF REU program for CEA education.
- The **University of Georgia** presented at a workshop sponsored by USDA, DoE, and NASA and organized a CEA Growers Day, engaging industry stakeholders. They also presented at the Southeastern Fruit and Vegetable Growers Association meeting. Their CEA Integrated Pest Management Lab interacted with and visited numerous Georgia CEA growers, and their Urban and Controlled Environment Pathology Lab provided technical support and diagnostics to urban and CEA facilities across the state.

- **Cornell University** collaborated with **North Carolina State University** on two studies using data-driven nutrient interpretation for greenhouse lettuce and with the **University of Minnesota** and **UC Davis** on using Plasma Activated Water (PAW) to enhance tomato seed germination and nutrition. They are also modeling the impact of climate on teen-leaf lettuce cultivars.
- **Universidad Autónoma Agraria Antonio Narro (México)** has MSc students researching techniques to increase plant tolerance to suboptimal illumination for energy saving and to enhance anticancer alkaloid production in vinca through indoor cultivation.
- The **University of Florida** collaborated with **Auburn University** on tomato growth data collection for crop modeling (USDA SAS project) and with Dr. Celina Gomez on a USDA AFRI project to develop energy models for indoor propagation systems.
- **Auburn University**'s poultryponics team studied the impact of biological wastewater treatment on hydroponic lettuce. Their aquaponics team conducted experiments on system optimization, including probiotic use in Tilapia and leafy vegetable production. They also used a split-root technique for salinity tolerance and conducted sensory evaluations. The GRACE project at AU, led by Brendan Higgins, focused on energy usage in low-tech greenhouses. Team members also collaborated with private industry and an economic development team from Alabama.
- **North Carolina State University Phytotron** evaluated different fertilizers and substrates for plant growth and is testing various LED light settings in comparison to traditional lighting in their growth chambers, aiming to optimize lighting for different crops.

These activities highlight a strong emphasis on collaborative research across institutions, engagement with industry and community partners, and a commitment to advancing knowledge and practices in controlled environment agriculture.

3.D. Milestones

Several milestones highlight the progress and future directions of this multistate group, often involving collaborations and external partnerships.

- **Rutgers University** plans to complete M.S. and Ph.D. theses and publish further research on life cycle assessment. They also aim to present conference papers on their agrivoltaics work, which involves regional and national partners.
- **Resource Innovation Institute (RII)** completed a CEA technology catalog to drive utility incentives, developed a site feasibility tool, and a public database of grants. Notably, RII established five industry/academic working groups spanning multiple states, focused on AI & Robotics, Energy Management, Greenhouse Colocation, High-Tech and Low-Tech Greenhouse Efficiency, demonstrating strong multistate engagement. They also developed best practices guides and an advanced credentialing program.
- The **University of Delaware**, **Arizona State University**, and **Colorado State University** are collaboratively developing open-access teaching modules for hydroponic lab activities, slated for completion in Fall 2025, an effort to enhance educational resources across institutions. The University of Delaware is also preparing conference presentations and publications on various CEA topics.

- **Cal Poly Pomona** anticipates full deployment of their machine-learning-supported greenhouse energy web-tool by Fall 2025, with pilot testing at collaborating institutions. They also expect to analyze yield trials from their NFT system and mushroom pod by Summer 2025 and complete the integration of real-time controls in their systems by Winter 2025.
- The **University of Georgia** reported the graduation of 9 graduate students and completion of grants leading to 15 referred papers. They hired new researchers focused on cucurbit and tomato research, automated phenotyping, and integrated pest management in protected agriculture, expanding their research capacity.
- The **University of Talca, Chile** is developing a research laboratory focused on soilless cultivation and vertical farming, indicating an expansion of their CEA research infrastructure.
- **Cornell University**, in collaboration with **Rutgers University** and **Rensselaer Polytechnic Institute**, held the GLASE Summit for CEA industry members, providing technical information on lighting, AI, and climate control, demonstrating a strong industry and multistate academic linkage.
- **Universidad Autónoma Agraria Antonio Narro (México)** anticipates the complete equipping of their vertical agriculture laboratory by 2025, which will enable future research on water and energy efficiency.
- The **University of Florida** installed energy and environmental monitoring sensors at commercial farms for a USDA AFRI project (PI: Celina Gomez, **Purdue University**), a collaboration with another institution and industry. They also developed computational fluid dynamics (CFD) models for greenhouse environmental simulation through a USDA SAS project (PI: Brandon Higgins, **Auburn University**), another multistate collaboration.
- The **University of Idaho** concluded that their micropropagation protocol for *Mirabilis macfarlanei* could be applied to other *Mirabilis* species for initial stages, but later stages require species-specific adjustments.
- **Auburn University** increased its CEA research capacity by adding three new container farms and planning the conversion of another into a growth chamber. They also celebrated the second year of their NIFA SAS project with a symposium hosted at the **University of Florida**, highlighting a collaborative research endeavor.
- The **North Carolina State University Phytotron** reported that their Centennial Campus growth facilities are open and operating successfully, servicing numerous academic and commercial research projects.

These milestones reflect significant progress in research infrastructure, technology development, educational resources, and collaborative initiatives across the multistate group, often involving partnerships with other universities, industry, and federal agencies.

3.E. Other accomplishments and activities

- **McGill University** obtained a university-wide cannabis license, enabling research from cultivation to extraction, and is collaborating with their medical school on human cell line testing, with one paper published.

- **Rutgers University** is a partner in the USDA-funded ADVANCEA project, along with **The Ohio State University**, **Cornell University**, and the **University of Arizona**, and commercial entities. The team offered an online introductory course on greenhouse environmental control. Additionally, Rutgers is leading a significant agrivoltaics initiative with $3M in state funding and secured a $1.6M DOE grant (FARMS) in collaboration with **Delaware State University**, American Farmland Trust, and the National Renewable Energy Laboratory for research and outreach across three university farms.
- **Texas A&M University** hosted a conference on controlled environment strawberry production and reported research on the interactive effects of light and temperature on lettuce growth and quality, as well as the impact of biostimulants on onion. They also studied cultivar-specific responses of spinach to root zone cooling, developed a robotic lettuce harvester, and employed AI for tomato disease detection and optimizing space utilization in hydroponics. Additionally, they researched lettuce growth in lunar regolith simulants, relevant to space agriculture.
- **PP Systems** announced new ownership and a rebranding initiative. Their webinar series continued, and their partnership with Cider Hill Farm in Massachusetts supported physiological research on various crops, including far-red light studies. They are also developing a shipping container vertical farm for plant physiology and CEA research, welcoming collaborations.
- **Conviron & Argus Controls** highlighted their collaborations with several universities: the **University of Illinois Urbana-Champaign** on bioenergy grass research, **Kansas State University** on wheat improvement, **Iowa State University** on upgrading plant growth chambers, and their financial support and research collaboration with the **North Carolina State University** CEA Coalition.
- **North Dakota State University** reported findings on hydroponic pH tolerance in lettuce, evaluation of bio-substrates, and improved sensor calibration using machine learning.
- **Resource Innovation Institute (RII)**, in partnership with **Berkeley Lab (LBNL)**, progressed on a DOE project, the 'CEA Market Accelerator'.
- The **University of Wyoming Plant Growth & Phenotyping Facility (PGPF)** coordinated an interdisciplinary CEA class, developed a Virtual Reality program, and supported multiple extramural collaborative proposals. They are also involved in a cross-state collaborative project on tribal community resilience with **New Mexico** and **South Dakota**, and Dr. Guadagno was added as a state representative to the NC1212 HATCH Project. They hosted a high-throughput phenotyping workshop with **PhotosynQ Inc.** and are developing an MOU to build a network for youth education in CEA.
- The **University of Hawaii at Manoa** demonstrated the enhanced growth of green onions under red LED lighting and showcased their CEA lab and research at campus-wide events to engage students and the public.
- The **University of Guelph Controlled Environment Systems Research Facility (CESRF)** collaborated with the **Canadian Space Agency**, **Canadensys Aerospace**, and **McGill University** on developing and testing a prototype lunar lander for plant production under reduced atmospheric pressure.
- The **University of California, Davis** investigated ground source heat pumps for greenhouses, the impact of far-red light on cilantro, global modeling of lettuce production, and provided technical assistance to local nursery greenhouse growers. They

also initiated an AES project on tomato transplants and are studying water use, fertilizer concentration, and dynamic lighting.

4. Impact statements

The research and outreach efforts of this multistate group are generating significant impacts on the controlled environment agriculture (CEA) industry, ranging from energy savings and improved crop quality to workforce development and sustainable practices.

- **McGill University**'s findings on the benefits of amber light are being shared, with potential for adoption by other researchers and growers.
- **Rutgers University** estimates their research and outreach have led to substantial annual savings for greenhouse operations through improved designs and operational strategies. Their energy conservation and crop lighting information has enabled growers to achieve energy savings of 5-30%. The ADVANCEA project, involving **Ohio State**, **Cornell**, and **Arizona**, is directly contributing to workforce development through online courses.
- **Texas A&M University**'s work on lighting and temperature control, autonomous harvesting, disease detection using AI, and optimized plant spacing aims to improve crop yield and quality while reducing costs and addressing labor shortages, ultimately making locally grown produce more accessible. Their AI-driven disease detection offers affordable, real-time solutions, particularly beneficial for new and smaller-scale growers, promoting sustainable practices.
- **North Dakota State University**'s research on water quality management, bio-substrates, and sensor technology provides growers with cost-effective and sustainable options. Their graduate training and the North Dakota CEA Conference, which included participation from **USDA ARS** and the **University of Minnesota**, are fostering regional collaboration and workforce development.
- **Percival Scientific**'s involvement in lighting uniformity regulations and their work on low GWP refrigerants and improved humidification technologies contribute to industry standards and more sustainable environmental control.
- **The Ohio State University**, through the online Indoor Ag Science Café series with partners in **Michigan**, **Indiana**, and **Arizona**, has reached a large audience with information on indoor farming technologies. Their nutrient optimization and substrate selection projects provide growers with practical guidance for efficient and sustainable production.
- **Resource Innovation Institute (RII)** is disseminating CEA best practices through various channels and expanding work with state and federal partners across multiple states (California, Maryland, New York, Pennsylvania, Virginia) on efficiency initiatives. Their Farm Parks Initiative promotes high-tech agricultural clusters.
- The **University of Wyoming Plant Growth & Phenotyping Facility (PGPF)** serves as a hub for interdisciplinary collaboration, aiming to develop a skilled workforce and economic resilience in the region through sustainable innovation and education in CEA.
- The **University of Hawaii at Manoa**'s research on LED lighting for green onions offers growers specific guidance for optimizing growth. Their outreach efforts at campus events are increasing public awareness and engagement with CEA.

- The collaborative research of the **University of Minnesota**, **Cornell University**, and **UC Davis** on plasma-activated water (PAW) demonstrates a sustainable alternative to synthetic chemicals, with proven benefits for pest management and seedling vigor.
- The collaboration between the **University of Delaware** and Croda, Inc. has identified an effective biostimulant for reducing tipburn in lettuce, a major economic concern, with active dissemination to industry stakeholders.
- **Cal Poly Pomona**'s web-based energy decision-support tool aids in designing more sustainable CEA facilities. Their integration of open-source controls in educational settings provides low-cost automation templates. Student-led research is contributing to AI-driven smart farming systems.
- The **University of Wyoming**'s work with the Restoring Shoshone Ancestral Food Group highlights the potential of CEA to support traditional food culture and sustainability in tribal communities.
- The research from the **University of Georgia** provides data-driven insights for optimizing various environmental factors and technologies in CEA, leading to improved crop quality, resource efficiency, and sustainability. Their breeding programs are developing cultivars better suited for controlled environments. The establishment of new labs focused on plant phenotyping and pathology addresses critical needs in the CEA sector.
- **Cornell University**'s work on energy-efficient lighting control systems, developed in collaboration with New York State greenhouses, demonstrates significant potential for energy savings and improved crop yields. Their development of proactive methods for detecting nutrient deficiencies contributes to more sustainable and productive practices.
- **Universidad Autónoma Agraria Antonio Narro (México)**'s research is advancing technology for plant and lighting management in indoor vertical farms, supported by industry funding. Their training programs are building capacity in LED lighting, hydroponics, and environmental control for students.
- The modeling work at the **University of Florida** is guiding the improved design and climate control of CEA systems, aiming to enhance plant and energy use efficiency.
- The **University of Idaho**'s work on micropropagation supports the conservation and restoration of native endangered plants, providing healthy plants for reintroduction. Their research on split-root techniques at **Auburn University** enables growing crops in higher salinity water, potentially integrating vegetable production with brackish water aquaculture.
- **Auburn University**'s development of a food safety training program for CEA producers and their postharvest quality studies on lettuce address critical food safety concerns. Their FoodU program is training students in modern food production techniques. Their aquaponics research program is part of a USDA-NIFA funded project led by **UC-Riverside** to mitigate antimicrobial resistance.
- The **North Carolina State University Phytotron** continues to modernize its facilities, supporting both academic and commercial research in the region.
- The **University of California, Davis** organized webinars on water and nutrient use efficiency and engaged high school students and educators with indoor farming concepts, contributing to workforce development and sustainable practices. Their research aims to optimize nursery practices and improve resource efficiency in CEA.

Collectively, these impact statements underscore the significant contributions of this multistate group to advancing the CEA industry through innovative research, technology development, education, and outreach, often through collaborative efforts.

5. Published written works

5.A. Books

- None.

5.B. Book chapters

- Graham, T. 2024. The promise and pitfalls of controlled environment agriculture (CEA) - technological, biological, and societal considerations for an evolving agricultural landscape. In Future Food Systems: Exploring Global Production, Processing, Distribution and Consumption. Editor(s): Rickey Y. Yada, Rene Van Acker, Martin Scanlon, David Gray. Academic Press, Pages 43-54 https://doi.org/10.1016/B978-0-443-15690-8.00023-0
- Leonardos, E.D., Marie,T.R., & Grodzinski, B. (2024). Quantifying Daily Growth Patterns Non-destructively Using Whole-Plant CO2 and H2O Exchange Is a Powerful Tool for Phenotyping. In Handbook of Photosynthesis. Chapter 24: pp 474-497; edit M Pessarklia. Published, CRC Press, Boca Raton, Fl., USA

5.C. Refereed journal articles

- Ahrens, A. 2024. Photoperiod and Fertigation Strategies for Controlled Environment Cannabis Production. MSc. School of Environmental Sciences, University of Guelph, Guelph, Ontario
- Ahrens, A., Llewellyn, D. & Zheng, Y. 2024. Longer photoperiod substantially increases indoor-grown cannabis' yield and quality: A study of two high-THC cultivars grown under 12 h vs. 13 h days. Plants, 13(3), 433; https://doi.org/10.3390/plants13030433.
- Ahsan, T. A., Rahman, M. S., & Ahamed, M. S. (2025). Geothermal energy application for greenhouse microclimate management: A review. Geothermics, 127, 103209.
- Akter, N., Cammarisano, L., Taylor, G., Naznin, M. T., Verdonk, J. C., & Ahamed, M. S. (2024). Impact of light spectral combinations on morphology, yield, and quality of indoor-grown cilantro. *Frontiers in Sustainable Food Systems*, *8*, 1499954.
- Akter, N., Cammarisano, L., Taylor, G., Naznin, M. T., Verdonk, J. C., & Ahamed, M. S. (2024). Impact of light spectral combinations on morphology, yield, and quality of indoor-grown cilantro. *Frontiers in Sustainable Food Systems*, *8*, 1499954.
- Ali, Awais, Genhua Niu, Joseph Masabni, Antonio Ferrante, and Giacomo Cocetta. 2024. Integrated nutrient management of fruits, vegetables and crops through the use of biostimulants, soilless cultivation, and traditional and modern approaches – A mini review. Agriculture 2024, 14, 1330, https://doi.org/10.3390/agriculture1401330.
- Alvarado-Camarillo, D., Valdez-Aguilar, L. A., Cartmill, D. L., & Cartmill, A. D. (2024). Strawberry Grown in an Indoor Vertical Farm Responds to Increased Photosynthetic

Photon Flux Density When Calcium Is Supplied at Higher Concentrations. *HortScience 59*(12), 1806-1814.

- Amrhein, J., F. Rotondo, C. Kubota, S.A. Miller, and A.L. Testen 2024. Diagnostic guide for Pythium root rot in hydroponic leaf green and herb production. Plant Health Progress. https://apsjournals.apsnet.org/doi/10.1094/PHP-07-24-0070-DG
- Antoszewski, G., Guenther, J.F., Roberts III, J.K., Adler, M., Dalle Molle, M., Kaczmar, N.S., Miller, W.B., Mattson, N.S. and Grab, H., 2024. Non-Invasive Detection of Nitrogen Deficiency in Cannabis sativa Using Hand-Held Raman Spectroscopy. Agronomy, 14(10), p.2390.
- Arthur, W., C.K. Akplah, E.T. Drabold, S. Manjankattil, J. Smith, D.E. Wells, D.V. Bourassa, B.T. Higgins. 2024. Dosing *Salmonella* into Poultryponics: Fate of *Salmonella* during treatment of poultry processing wastewater and irrigation of hydroponic lettuce. Journal of Environmental Management. 377: 124559. https://doi.org/10.1016/j.jenvman.2025.124559
- Arthur, W., Z. Morgan, A.E. Inskeep, C. Browne, D.E. Wells, D.V. Bourassa, B.T. Higgins. 2024. Poultryponics: Cultivation of hydroponic lettuce using treated poultry processing wastewater for increased nitrogen neutrality. Bioresource Technology. 422: 132227. https://doi.org/10.1016/j.biortech.2025.132227
- Arthur, W., Z. Morgan, M. Reina, E. Drabold, D.E. Wells, D.V. Bourassa, Q. Wang, B.T. Higgins. 2024. Pilot-Scale Evaluation of Poultryponics: Insights into Nitrogen Utilization and Food Pathogen Dynamics. ACS ES&T Water. 4(9): 3964-3975. https://doi.org/10.1021/acsestwater.4c00262
- Bashir, Al, Yaqoob Majeed, and Azlan Zahid. 2024. "Development of an End-Effector for Robotic Harvesting of Hydroponic Lettuce." In 2024 ASABE Annual International Meeting, Paper Number: 2400401 doi:10.13031/aim.202400401
- Bhattarai, K., Ogden, A. B., Pandey, S., Sandoya, G. V., Shi, A., Nankar, A. N., ... & Dardick, C. (2025). Improvement of crop production in controlled environment agriculture through breeding. Frontiers in Plant Science, 15, 1524601.
- Carrasco, G.; Fuentes-Peñailillo, F.; Manríquez, P.; Rebolledo, P.; Vega, R.; Gutter, K.; Urrestarazu, M. Enhancing Leafy Greens' Production: Nutrient Film Technique Systems and Automation in Container-Based Vertical Farming. Agronomy 2024, 14, 1932. https://doi.org/10.3390/agronomy14091932
- Chen J, Keith JF, DA Claypool. 2025. Growth and physiological responses of three culturally significant native edible berry species to controlled-release fertilizer in greenhouse conditions. HortScience 60:729-737. https://doi.org/10.21273/HORTSCI18452-25
- Chiu, L.V., Nicholson, C.F., Gómez, M.I. and Mattson, N.S., 2024. A meta-analysis of yields and environmental performance of controlled-environment production systems for tomatoes, lettuce and strawberries. Journal of Cleaner Production, 469, p.143142.
- Chowdhury M., A. Espinoza, U.C. Samarakoon, J. Altland, and T. Yang. 2024. Substrate comparison for tomato propagation under different fertigation protocols, Agriculture Special issue Special Issue Innovative Technologies for Sustainable Crop Production in Controlled Environment. Agriculture 2024, 14(3), 382; https://doi.org/10.3390/agriculture14030382

- Chowdhury M., U.C. Samarakoon, and J.E. Altland. 2024. Evaluation of hydroponic systems for organic lettuce production in controlled environment. Front. Plant Sci. 15:1401089. doi: 10.3389/fpls.2024.1401089
- David Rasmussen, Kirsten A. Lahre, Dorith Rotenberg, Anna E. Whitfield,
- Desaulniers Brousseau, V., B. Goldstein, C. Sedlock, M. Lefsrud. 2024. The Environmental Impact of Outdoor Cannabis Production. ACS Agricultural Science & Technology. 4:690−699
- Desaulniers Brousseau, V., B. Goldstein, M. Lachapelle, I. Tazi. M.G. Lefsrud. 2024. Greener green: The environmental impacts of the Canadian cannabis industry. Resource, Conservation and Recycling 208: 107737.
- Desaulniers Brousseau, V., B. P. Goldstein, D. Leroux, T. Giguère, S. MacPherson, M. Lefsrud. 2024. Estimating the global warming potential of animal waste-based organic liquid fertilizer for urban hydroponic farms. Journal of Cleaner Production 472(2024)143434.
- Desaulniers Brousseau, V., E. Bahl, A. Robichaud, M. Lefsrud. 2024. Fungal Contamination Monitoring in Legal Cannabis Products Using UHPLC-MS/MS. Journal of Testing and Evaluation 52(6):1-21
- Dsouza*, A., Newman, L., Graham, T., Fraser, E.D.G., 2023. Exploring the landscape of controlled environment agriculture research: A systematic scoping review of trends and topics. Agric. Syst. 209, 103673.
- Dsouza, A., Dixon, M., Shukla, M., & Graham, T. 2025. Harnessing controlled-environment systems for enhanced production of medicinal plants, Journal of Experimental Botany, 76:76–93, https://doi.org/10.1093/jxb/erae248
- Eduardo J. Haverroth, Cristiane J. Da-Silva, Matthew Taggart, Leonardo A. Oliveira, and Amanda A. Cardoso. 2024. Shoot hydraulic impairments induced by root
- Eli D. Hornstein, Melodi Charles, Megan Franklin, Brianne Edwards, Simina Vintila,
- Fuentes-Peñailillo, F.; Gutter, K.; Vega, R.; Silva, G. Carrasco. New Generation Sustainable Technologies for Soilless Vegetable Production. Horticulturae 2024, 10, 49. https://doi.org/10.3390/horticulturae10010049
- Fuentes-Peñailillo, F.; Gutter, K.; Vega, R.; Silva, G. Carrasco. Transformative Technologies in Digital Agriculture: Leveraging Internet of Things, Remote Sensing, and Artificial Intelligence for Smart Crop Management. J. Sens. Actuator Netw. 2024, 13, 39. https://doi.org/10.3390/jsan13040039
- Greiss P.M., J.D. Rich, G.A. Mackay, D. Nguyen, M.G. Lefsrud, D.H. Eidelman, C.J. Baglole. 2024. The effect of cannabis-derived terpenes on alveolar macrophage function. Frontiers of Toxicology 6:1504508. doi: 10.3389/ftox.2024.1504508
- Hirst, A.; Anee, S. A.; Housley, M. J.; Qin, K.; Ferrarezi, R. S.* 2024. Selected Beneficial microbes alleviate salinity stress in hydroponic lettuce and pak choi. *HortTechnology* 34(3): 345–352. DOI: 10.21273/HORTTECH05403-24
- Hitti, Y., I. Buzatu, M.D. Verme, M. Lefsrud, F. Golemo, A. Durand. 2024. GrowSpace: A reinforcement learning environment for plant architecture. Computers and Electronics in Agriculture 217(108613):1-10.
- Ikram, Muhammad, Sikander Ameer, Fnu Kulsoom, Mazhar Sher, Ashfaq Ahmad, Azlan Zahid, and Young Chang. 2024. “Flexible Temperature and Humidity Sensors of Plants

for Precision Agriculture: Current Challenges and Future Roadmap." Computers and Electronics in Agriculture 226:109449.

- Iradukunda, M.; van Iersel, M. W.; Seymour, L.; Lu, G.; Ferrarezi, R. S.* 2024. Automated imaging to evaluate the exogenous gibberellin (GA_3) impact on seedlings from salt-stressed lettuce seeds. *Sensors* 24(13): 4228. DOI: 10.3390/s24134228
- Iradukunda, M.; van Iersel, M. W.; Seymour, L.; Lu, G.; Ferrarezi, R. S.* 2024. The use of imaging to quantify the impact of seed aging on lettuce seed germination and seedling vigor. *Sensors* 24(13): 4235. DOI: 10.3390/s24134235
- Iradukunda, M.; van Iersel, M. W.; Seymour, L.; Lu, G.; Ferrarezi, R. S.* 2024. Low-cost imaging to quantify germination rate and seedling vigor across lettuce cultivars. *Sensors* 24(13): 4225. DOI: 10.3390/s24134225
- James Reynolds, Michael Wilkins, Devon Martin, Matthew Taggart, Kristina R. Rivera, Meral Tunc-Ozdemir, Thomas Rufty, Edgar Lobaton, Alper Bozkurt and Michael A. Daniele. 2024. Sensors 24:2335. https://doi.org/10.3390/s24072335 https://www.mdpi.com/journal/sensors
- Jang, MJ., Cho, H.J., Park, YS. et al. Haplotype-resolved genome assembly and resequencing analysis provide insights into genome evolution and allelic imbalance in Pinus densiflora. Nat Genet 56, 2551–2561 (2024). https://doi.org/10.1038/s41588-024-01944-y
- Jean Beagle Ristaino. 2024. Disease Progress and Detection of a California Resistance-Breaking Strain of Tomato Spotted Wilt Virus in Tomato with LAMP and CRISPR-Cas12a Assays. PhytoFrontiersTM 4:50-60 https://doi.org/10.1094/PHYTOFR-05-23-0058-FI
- Jeana Hansel, Amanda C. Saville, and Jean Beagle Ristaino. 2024. Evaluation of a Formulation of Bacillus subtilis for Control of Phytophthora Blight of Bell Pepper, Plant Disease 108:1014-1024 https://doi.org/10.1094/PDIS-04-23-0807-RE
- Jeong, Sangjun, Qianwen Zhang, Genhua Niu, and Shuyang Zhen. 2024. The interactive effects between far-red light and temperature on lettuce growth and morphology diminish at high light intensity. Frontiers in Plant Science. DOI 10.3389/fpls.2024.1497672.
- Jeong, Sangjun, Qianwen Zhang, Genhua Niu, and Shuyang Zhen. 2024. Synergistic enhancement of biomass allocation from leaves to stem by far-red light and warm temperature can lead to growth reductions. Environmental and Experimental Botany. doi.org/10.101016/j.envexpbot.2024.106024.
- Jeong, Sangjun, Qianwen Zhang, Shuyang Zhen, Genhua Niu. 2025. Lowering light intensity while extending photoperiod at a constant daily light integral synergistically interact with warm temperature to enhance leaf expansion and crop yield in lettuce in the absence of far-red light. Front. Plant Sci. 16:1529455. doi: 10.3389/fpls.2025.1529455
- Jonathan E. Oliver, Dorith Rotenberg, Karolyn Agosto-Shaw, Holly A. McInnes, Kirsten A. Lahre, Michaël Mulot, Sott Adkins, and Anna E. Whitfield. 2024. Multigenic Hairpin Transgenes in Tomato Confer Resistance to Multiple Orthotospoviruses Including Sw-5 Resistance-Breaking Tomato Spotted Wilt Virus, Phytopathology® 114:1137-1149 https://doi.org/10.1094/PHYTO-07-23-0256-KC
- K Lindelof, A Krings, N Giertych. 2025. Scientific Note: the Role of Pre-stratification Dry Storage Time in Germination Success of an Imperiled, Southern Appalachian Endemic, Houstonia montana, Castanea, 89(2):196-208. https://doi.org/10.2179/0008-7475.89.2.196

- Kang, L., Zhang, Y., Kacira, M., & van Hooff, T. (2024). CFD simulation of air distributions in a small multi-layer vertical farm: Impact of computational and physical parameters. Biosystems Engineering, 243, 148-174. https://doi.org/10.1016/j.biosystemseng.2024.05.004
- Kang, S., Parrish, C.H., Hebert, D., and Zhen S. . (2024) Luminescent quantum dot films increase the radiation capture and yield of lettuce and sweet basil compared to a traditional/neutral-density greenhouse glazing. *HortScience 59*: 988-996 https://doi.org/10.21273/HORTSCI17921-24
- Kim S-B, Kim K-T, In S, Jaiswal N, Lee GW, Jung S, et al. 2024. Use of the Puccinia sorghi haustorial transcriptome to identify and characterize AvrRp1-D recognized by the maize Rp1-D resistance protein. PLoS Pathog 20(11):e1012662. https://doi.org/10.1371/journal. ppat.1012662
- Kong, Y., & Zheng, Y. 2023. Magic blue light: A versatile mediator of plant elongation. Plants, 13(1), 115.
- Kong, Yun, and Youbin Zheng. 2024. "Diverse Flowering Response to Blue Light Manipulation: Application of Electric Lighting in Controlled-Environment Plant Production" Horticulturae 10, no. 6: 578. https://doi.org/10.3390/horticulturae10060578
- Kpai, P.Y., O. Adaramola, P.W. Addo, S. MacPherson M. Lefsrud. 2024. Mineral nutrition for Cannabis sativa in the vegetative stage. Plant Science 15(2024):1-17.
- Kuruppuarachchi, Chamika, Fnu Kulsoom, Hussam Ibrahim, Hamid Khan, Azlan Zahid, and Mazhar Sher. 2024. “Advancements in Plant Wearable Sensors.” Computers and Electronics in Agriculture 229: 109778.
- L. Bovet, J. Battey, J. Lu, N. Sierro, R. E. Dewey and S. Goepfert. 2024. Nitrate assimilation pathway is impacted in young tobacco plants overexpressing a constitutively active nitrate reductase or displaying a defective CLCNt2. BMC Plant Biology (2024) 24:1132 https://doi.org/10.1186/s12870-024-05834-7
- Lindsey E. Becker and Marc A. Cubeta. 2024. Multigenerational Drought Reveals a Stable Wheat Seed Fungal Community, Environmental Microbiology Reports, Doi: 10.1111/1758-2229.70004
- Lindsey E. Becker and Marc A. Cubeta. 2024. Multigenerational Drought Reveals a Stable Wheat Seed Fungal Community, Phytobiomes Journal 8:262-271 https://doi.org/10.1094/PBIOMES-08-23-0083-R
- Liu, Jun, Qianwen Zhang, Joseph Masabni, and Genhua Niu. 2024. Low nitrogen availability in organic fertilizers limited organic watermelon transplant growth. Horticulturae 2024, 10, 1140.https://doi.org/10.3390/horticulturae10111140.
- Loh, K.Q., K. Harbick, N.J. Eylands, U.R. Kortshagen, and V.E. Ferry. 2024. Design guidelines for luminescent solar concentrator greenhouses in the United States. Adv. Sustainable Systems. 9:2400749.
- Ly, V. & Zheng, Y. 2025. Alleviation of Chilling Injury in Postharvest Sweet Basil (*Ocimum basilicum* L.) with Silicon and Abscisic Acid Applications. Agriculture 2025, 15(6), 643; https://doi.org/10.3390/agriculture15060643
- Majeed, Yaqoob, Mike O. Ojo, and Azlan Zahid. 2024. “Standalone Edge AI-Based Solution for Tomato Diseases Detection.” Smart Agricultural Technology 9: 100547.
- Manuel Kleiner, Heike Sederoff. 2024. IPD3, a master regulator of arbuscular mycorrhizal symbiosis, affects genes for immunity and metabolism of non-host

Arabidopsis when restored long after its evolutionary loss. 2024. Plant Molecular Biology (2024) 114:21 https://doi.org/10.1007/s11103-024-01422-3

- Marie, T. R., Leonardos, E. D., Rana, N., & Grodzinski, B. 2024. Tomato and mini-cucumber tolerance to photoperiodic injury involves photorespiration and the engagement of nighttime cyclic electron flow from dynamic LEDs. Frontiers in Plant Science, 15, 1-21. DOI 10.3389/fpls.2024.1384518
- Mayorga, A.; van Iersel, M. W.; Ferrarezi, R. S.* 2024. Lowering the target daily light integrals following days with excessive lighting can reduce lettuce production costs. *Frontiers in Plant Sciences* 15: 1467443. DOI: 10.3389/fpls.2024.1467443
- Mayorga, A.; van Iersel, M. W.; Ferrarezi, R. S.* 2024. Varying light intensities affect lettuce growth and physiology in controlled indoor environments. *Horticulturae* 10(9): 931. DOI: 10.3390/horticulturae10090931
- Meng, Q.* and I. Kelly. 2024. Efficacy and optimal timing of warm-white or red + far-red LED lamps in regulation of flowering in long-day ornamentals. HortScience 59(6):767–776. [CrossRef].
- Meng, Q.* and T.J. Kramer. 2024. Increasing the nighttime lighting duration can hasten flowering of long-day plants. HortScience 59(12):1833–1837. [CrossRef]
- Menon, R., A.J. Both, and F. You. 2025. A life cycle assessment and techno-economic analysis of plant factories. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2025.144741
- Meskher, H., Thakur, A., Hazra, S. K., Ahamed, M. S., Saleque, A. M., Alsalhy, Q. F., ... & Lynch, I. (2025). Recent advances in applications of MXenes for desalination, water purification and as an antibacterial: a review. Environmental Science: Nano.
- Mickos, V.P., Blanchard, C., Pizzo, J.S., Kitchens, S., Price, S., Wells, D., Rodrigues, C. Controlling *Salmonella enterica* in Water Recirculating Systems for Lettuce Production using a Bacteriophage Cocktail (Accepted in HortScience in May 2025).
- Moher, M., Llewellyn, D., Golem, S., Foley, E., Dinka, S., Jones, M., & Zheng, Y. 2023. Light Spectra Have Minimal Effects on Rooting and Vegetative Growth Responses of Clonal Cannabis Cuttings. HortScience, 58(2), 215-221. https://doi.org/10.21273/HORTSCI16752-22
- Muhammad Irfan Siddique, Emily Silverman, Frank Louws and Dilip R. Panthee. 2024. Quantitative Trait Loci Mapping for BacterialWilt Resistance and Plant Height in Tomatoes. Plants, 13, 876. https://doi.org/10.3390/plants13060876 https://www.mdpi.com/journal/plants
- Ojo, Mike O., Azlan Zahid, and Joseph G. Masabni. 2024. “Estimating Hydroponic Lettuce Phenotypic Parameters for Efficient Resource Allocation.” Computers and Electronics in Agriculture 218: 108642.
- Oliveira, B. Padeniya, U., Bledsoe, J.W., Davis, D.A., Liles, M.R., Hussain, A.S., Wells, D.E., and T.J. Bruce. 2025. Evaluation of probiotic effects on the growth performance and microbiome of Nile tilapia (Oreochromis niloticus) in a high-density biofloc system. Aquaculture Nutrition. 2025, 5868806. https://doi.org/10.1155./anu/5868806
- Palsha. P. L.; van Iersel, M. W.; Dickson, R. W.; Seymour, L.; Yelton, M.; Ferrarezi, R. S.* 2024. Strategic light use efficiency optimization of hydroponic lettuce exposed to different photosynthetic photon flux densities. *Agronomy* 14(10): 2281. DOI: 10.3390/agronomy14102281

- Palsha. P. L.; van Iersel, M. W.; Dickson, R. W.; Seymour, L.; Yelton, M.; Ferrarezi, R. S.* 2024. Morphological and physiological changes of hydroponic lettuce grown in varying potassium concentrations and an adaptive lighting control system. *HortScience* 59(8): 1097-1105. DOI: 10.21273/HORTSCI17806-24
- Palsha. P. L.; van Iersel, M. W.; Dickson, R. W.; Seymour, L.; Yelton, M.; Ferrarezi, R. S.* 2024. Exploring leaf anthocyanin concentrations and light effects on lettuce growth. *Horticulturae* 10(5): 437. DOI: 10.3390/horticulturae10050437
- Park Y-G.; Schoeller, E. N.; Ahmed, M. Z.; McKenzie, C. L.; Osborne, L. S. 2025. Management of *Bemisia tabaci* MEAM1 (Hemiptera: Aleyrodidae) on poinsettia using a papaya banker plant system for the predator *Delphastus pallidus* (Coleoptera: Coccinellidae). *Biological Control* (in press).
- Qingming Li, David Llewellyn, Yun Kong, and Youbin Zheng. 2025. Narrowband blue LEDs with different peak wavelengths similarly promote seedling elongation and have greater promotion effects than ultraviolet A and far-red in two species of Brassicaceae. Canadian Journal of Plant Science. 105: 1-13. https://doi.org/10.1139/cjps-2024-0108
- Rebolledo, P.; Carrasco, G.; Moggia, C.; Gajardo, P.; Sant'Ana, G.R.; Fuentes-Peñailillo, F.; Urrestarazu, M.; Vendruscolo, E.P. Assessment of Vegetable Species for Microgreen Production in Unheated Greenhouses: Yield, Nutritional Composition, and Sensory Perception. Plants 2024, 13, 2787. https://doi.org/10.3390/plants13192787
- Reddy, S., L. McCartney, B.-S. Wu, P. W. Addo, S. MacPherson, M. Lefsrud. 2024. Amber LEDs outperform red, blue, and red-blue-amber LEDs for lettuce. The Journal of Horticultural Science & Biotechnology 99(6):721–737
- Renó, V., Cardellicchio, A., Romanjenko, B.C. and Guadagno, C.R., 2024. AI-assisted image analysis and physiological validation for progressive drought detection in a diverse panel of Gossypium hirsutum L. Frontiers in Plant Science, 14, p.1305292. https://doi.org/10.3389/fpls.2023.1305292
- Ries, J., Q. Meng, and Y. Park*. 2025. Potassium sulfate supplementation with elevated electrical conductivity was unproductive for hydroponic strawberry at the original Yamazaki nutrient solution nitrogen level. HortScience 60(2):198–204. [CrossRef]
- Rodrigues, C., Blanchard, C., Trandel-Hayse, M., Wells, D., Rehman, T. Post-harvest strategies to improve shelf-life of indoor-grown lettuce (accepted at Acta Horticulturae in November 2024).
- Rufyikiri A.-S., P. A. Wiredu, B.-S. Wu, S. MacPherson, V. Orsat, M. Lefsrud. 2024. The use of LEDs for the stomatal response, light compensation points, and storage of spinach and kale. Journal of Photochemistry & Photobiology 257(2024):112959
- Rufyikiri, S., Martinez, R., P.A. Addo, B.-S. Wu, M. Yousefi, D. Malo, V. Orsat, S. M. Vidal, J. H. Fritz, S. MacPherson, and M. Lefsrud. 2024. Germicidal efficacy of continuous and pulsed ultraviolet-C radiation on pathogen models and SARS-CoV-2. Photochemical & Photobiological Sciences 23: 339–354.
- Salehinia, S., F. Didaran, S. Aliniaeifard, S. Zohrabi, S. MacPherson, M. Lefsrud. 2024. Green light enhances the nutritional value and pigment preservation of lettuce during postharvest cold storage. PLoS ONE 19(11)1-18.
- Sanjana Banerjee, James Reynolds, Matthew Taggart, Michael Daniele, Alper Bozkurt and Edgar Lobaton. 2024. Quantifying Visual Differences in Drought-Stressed Maize through Reflectance and Data-Driven Analysis, AI, 5(2), 790-802; https://doi.org/10.3390/ai5020040

- Schembri, C., Kaczmar, N., Osborn, J., Timmons, M.B. and Mattson, N.S., 2025. Evaluation of Fish Biosolids as a Fertilizer for Organic Tomato Transplant Production. Horticulturae, 11(1), p.57.
- Schoeller, E. N.; Hogan J.; McKenzie, C. L.; Osborne, L. S. 2024. Functional response of *Franklinothrips vespiformis* (Thysanoptera: Aeolothripidae) to eggs and nymphs of *Bemisia tabaci* (Hemiptera: Aleyrodidae). *Journal of Insect Science* 24:1–9. DOI: 10.1093/jisesa/ieae030
- Sharkey, A.; Altman, A.; Cohen, A. R.; Groh, A. A. T.; Igou, T.; Ferrarezi, R. S.; Chen, Y. 2024. Modeling Bibb lettuce nitrogen uptake and biomass productivity in vertical hydroponic agriculture. *Agriculture* 14(8): 1358. DOI: 10.3390/agriculture14081358
- Silva, J. A. O. S.; Siqueira, V. S. de; Mesquita, M.; Vale, L. S. R.; Silva, J. L. B. da; Silva, M. V. da; Lemos, J. P. B.; Lacerda, L. N.; Ferrarezi, R. S.*; Oliveira, H. F. E. de. 2024. Artificial intelligence applied to support agronomic decisions for the automatic aerial analysis images captured by UAV: A systematic review. *Agronomy* 14(11): 2697; DOI: 10.3390/agronomy14112697
- Tatsiana Shymanovich, Amanda C. Saville, Noor Mohammad, Qingshan Wei,
- Tatsiana Shymanovich, Amanda C. Saville, Rajesh Paul, Qingshan Wei, and Jean Beagle Ristaino. 2024. Rapid Detection of Viral, Bacterial, Fungal, and Oomycete Pathogens on Tomatoes with Microneedles, LAMP on a Microfluidic Chip, and Smartphone Device. Phytopathology® 114:1975-1983 https://doi.org/10.1094/PHYTO-12-23-0481-R Techniques
- Terlizzese, D., Lanoue, J., Hao, X., & Zheng, Y. 2024. Light Environment and Photosynthetic Capacities of Leaves at Different Locations within Eggplant Canopies in a Greenhouse in Ontario, Canada. HortScience, 59(5), 678-683. https://doi.org/10.21273/HORTSCI17642-23
- Thakur, A. K., Hazra, S. K., Saleque, A. M., Bhattarai, S., Hwang, J. Y., & Ahamed, M. S. (2024). Toward Sustainable Water Solutions: A Review of Nanomaterials for Solar-Driven Water Harvesting. ACS ES&T Water, 4(11), 4741-4757.
- Thies, M.; Ferrarezi, R. S.*; Realff, M. 2024. Combined effect of light and temperature on wheat and rice growth: A case study in controlled environment agriculture. *Horticulturae* 14(8): 1641. DOI: 10.3390/agronomy14081641
- Trumpler, K., B.-S. Wu, P. W. Addo, S. MacPherson, M. Lefsrud. 2024. Plant growth optimization using amber light supplemented with different blue light spectra. Horticulturae 10(10):1097
- Valle de Souza, S., K.C. Shasteen, J. Seong, C. Kubota, M. Kacira, and H.C. Peterson. 2024. Production planning in an indoor farm: Using time and space requirements to define an efficient production schedule and farm size. International Food and Agribusiness Management Review. 27. DOI: 10.22434/IFAMR2023.0038
- Veazie, P., Chen, H., Hicks, K., Holley, J., Eylands, N., Mattson, N., Boldt, J., Brewer, D., Lopez, R. and Whipker, B.E., 2024. A Data-driven approach for generating leaf tissue nutrient interpretation ranges for greenhouse lettuce. HortScience, 59(3), pp.267-277.
- Veazie, P., H. Chen, K. Hicks, J. Holley, N.J. Eylands, N. Mattson, J. Boldt, D. Brewer, R. Lopez, and B.E. Whipker. 2024. A data-driven approach for generating leaf tissue nutrient interpretation ranges for greenhouse lettuce. HortScience. 59:267-277.
- Vosburg, C.; Sinn, J. P.; Orbovic, V.; Ferrarezi, R.S.; Zapien-Macias, J. M.; Taylor, E. L.; Hilf, M.; McCollum, G.; Gottwald, T. R.; Stover, E.; McNellis, T. W. 2024. Assessment

of grapefruit expressing anti-NodT antibody for Huanglongbing resistance. *PhytoFrontiers* 4(2): 172-182. DOI: 10.1094/PHYTOFR-06-23-0078-R

- Wacker, K.; Kim, C.; van Iersel, M. W.; Haidekker, M.; Seymour, L.; Ferrarezi, R. S.* 2024. Validation of in-house imaging system via code verification on petunia images collected at increasing fertilizer rates and pHs. *Sensors* 24(17): 5809. DOI: 10.3390/s24175809
- Wacker, K.; Kim, C.; van Iersel, M. W.; Sidore, B.; Pham, T.; Haidekker, M.; Seymour, L.; Ferrarezi, R. S.* 2024. Development of an automated low-cost multispectral imaging system to quantify canopy size and pigmentation. *Sensors* 24(17): 5515. DOI: 10.3390/s24175515
- waterlogging: Parallels and contrasts with drought. Plant Physiology, 197, kiae336 https://doi.org/10.1093/plphys/kiae336
- Weingarten, M., Mattson, N. and Grab, H., 2024. Evaluating propagation techniques for Cannabis sativa L. cultivation: A comparative analysis of soilless methods and aeroponic parameters. Plants, 13(9), p.1256.
- Wu, B.S., M. Mansoori, M. Schwalb, S. Islam, M. T. Naznin, P. W. Addo, S. MacPherson, V. Orsat, and M. Lefsrud. 2024. Light emitting diode effect of red, blue, and amber light on photosynthesis and plant growth parameters. Journal of Photochemistry & Photobiology 256: 112939
- Wu, B.S., P. Wiredu Addo, S. MacPherson, V. Orsat, M. Lefsrud. 2024. Updates to McCree's Photosynthetically Active Radiation Curve - 55 years later. Photochemistry & Photobiology B: Biology. JPHOTOBIOL-D-24-00899R4
- Xia, J. and Mattson, N., 2024. Daily Light Integral and Far-Red Radiation Influence Morphology and Quality of Liners and Subsequent Flowering and Development of Petunia in Controlled Greenhouses. Horticulturae, 10(10), p.1106.
- Yang, T., U.C. Samarakoon, and J. Altland. 2024. Growth, phytochemical concentration, nutrient uptake, and water consumption of butterhead lettuce in response to hydroponic system design and growing season. Scientia Horticulturae, 332, p.113201. https://doi.org/10.1016/j.scienta.2024.113201
- Yang, T., U.C. Samarakoon, J. Altland, and P. Ling. 2024. Influence of Electrical Conductivity on Plant Growth, Nutritional Quality, and Phytochemical Properties of Kale (Brassica napus) and Collard (Brassica oleracea) Grown Using Hydroponics. Agronomy 14, 2704. https://doi.org/10.3390/agronomy14112704
- Yu P.; Schoeller, E. N.; Joseph, S. V. 2024. Poinsettia Production. *University of Georgia Cooperative Extension*. Bulletin 1580.
- Zhang, Jinnuo, Xing Wei, Zhihang Song, Ziling Chen, and Jian Jin. "A high-precision spatial and spectral imaging solution for accurate corn nitrogen content level prediction at early vegetative growth stages." *Computers and Electronics in Agriculture* 230 (2025): 109940.
- Zhang, Qianwen, Joseph Masabni, Genhua Niu. Microbial Biostimulants and Seaweed Extract Synergistically Influence Seedling Growth and Morphology of Three Onion Cultivars. Horticulturae 2024, 10, 800. https://doi.org/10.3390/horticulturae10080800.
- Zhou, X., Y. Zhang, X. Jiang, K. Riaz, P. Rosenbaum, M. Lefsrud, S. Sun. 2024. Advancing tracking-by-detection with *MultiMap: Towards occlusion-resilient online multiclass strawberry counting.* Expert Systems With Applications 25b (1): 124587.

- Zhu, L., Gowda, S. A., & Kuraparthy, V. 2024. Fine mapping and targeted genomic analyses of photoperiod-sensitive gene (GB_PPD1) in Pima cotton (Gossypium barbadense L.). Crop Science, 64, 1756–1771. https://doi.org/10.1002/csc2.21250
- Zhu, Y., Singh, J., Patil, B., and Zhen, S.. (2024) End-of-production blue light intensity and application duration co-regulate anthocyanins and ascorbic acid production in red leaf lettuce. *Scientia Horticulturae* 335, 113333. https://doi.org/10.1016/j.scienta.2024.113333

5.D. Symposium proceedings

- Both, A.J., B. Bamka, T. Besançon, D.P. Birnie, III, C. Burgher, D. Giménez, S. Guran, M. Kornitas, P. Nitzsche, D. Robinson, W.R. Rucker, E. Schoolman, D. Specca, K.P. Sullivan, D.L. Ward, M. Westendorf, and C.A. Wyenandt. 2025. Lessons learned from three agrivoltaic installations in New Jersey. Accepted for Publication. 2024 Agrivoltaics World Conference, Denver, CO.
- Cammarisano, L., Frede, K., Graefe, J., Schreiner, M., Baldermann, S., & Körner, O. (2024, May). Pigment time-course of two lettuce cultivars in response to end-of-production blue-enhanced white light treatment. In X International Symposium on Light in Horticulture 1423 (pp. 47-54).
- Islam, M. N., Inam, A. S., Thakur, A. K., Ahamed, M. S., Ott, B., & Tabassum, S. (2024). A Cost-Effective Electrochemical Sensor for Real-Time Nitrate Monitoring in Hydroponics. *LPI Contributions*, *3065*, 5102.
- Loh, K.Q., K. Harbick, N.J. Eylands, U.R. Kortshagen, and V.E. Ferry. 2025. Luminescent solar concentrator greenhouses for concurrent energy generation and lettuce production in the United States. Agrivoltaics World Conference Proceedings, Denver, CO. June 11-13. pp. 1-8.

5.E. Presentations

- Ahamed, H.; Ahsan, T. M. A., M.; Ahamed, M. S. (2024). Evaluating the Energy Requirement of Indoor Container Farming across Diverse USA Climate Zones. ASABE Annual Meeting 2024, July 28-31, Anaheim, California.
- Ahsan, T. M. A; Ahamed, M. S. (2024). Exploring Trade-offs in Thermal and Economic Performance Across Different Collector Technologies for Solar-Thermally Cooled Greenhouses. ASABE Annual Meeting 2024, July 28-31, Anaheim, California.
- Ahsan, T.M.A; Ahamed, M. S. (2024). Hybrid Ground Source Heat Pump for Effectively Cooling and Dehumidifying Greenhouse Indoor Climate. ASABE Annual Meeting 2024, July 28-31, Anaheim, California.
- Bashir, Al, and Azlan Zahid. 2024. “Development of a Robotic End-Effector for Harvesting Greenhouse Hydroponic Lettuce.” American Society of Agricultural and Biological Engineers (ASABE), July 27-31, 2024.
- Bashir, Al, and Azlan Zahid. 2024. “Edge AI-Enabled Cutting Point Localization for Robotic Harvesting of Hydroponic Lettuce.” American Society of Agricultural and Biological Engineers (ASABE), Anaheim, July 27-31, 2024.

- Bashir, Al, and Azlan Zahid. 2024. "Real-Time Estimation of Strawberry Size, Weight and Level of Maturity: A Machine Learning Approach.", AI in Agriculture Conference, April 15-17, 2024.
- Blanchard, C., Trandel-Hayse, M., Rodrigues, C., Wells, D., and T. Rehman. 2024. Fresh weight of indoor-grown lettuce under different postharvest storage practices. HortScience 59(9):S379 – Presented at the 2024 ASHS Annual Conference. September 23-27, 2024. Honolulu, HI.
- Both, A.J. 2024. Measuring and controlling light. Cultivate'24. July 13.
- Both, A.J. 2025. Agrivoltaics 101. 70th New Jersey Agricultural Convention and Trade Show. February 5.
- Both, A.J. 2025. Greenhouses for homeowners and gardeners. Home Gardeners School, Rutgers Office of Continuing Professional Education. March 15.
- Cammarisano L., Frede K., Graefe J., Schreiner M., Baldermann S., Körner O. (2025) Pigment time-course of two lettuce cultivars in response to end-of-production blue-enhanced white light treatment. Acta Hortic - LightSym – 19-22 May 2024 – Seoul, Korea.
- Chen J, Jones SB, Dixon C, Massa GD, Monje O, and McBride SM. 2024. Quantifying impacts of engineered soil texture and layering on liquid- and gas-distribution for reduced gravity in containerized soils using numerical simulations. Lunar Surface Science Workshop (LSSW) 24: Science Drivers and Capabilities for Lunar Surface Habitat Research Facilities. https://www.hou.usra.edu/meetings/lunarsurface2020/ [Poster]
- Chen, J., N. Avriantari, S. B. Jones, G. D. Massa, J. F. Keith, and S. M. McBride. 2025. Evaluating Nutritional Quality and Palatability Characteristics of Lettuce Cultivated using Cut-and-Come-again Method under Two Irrigation Management Strategies. The Human Research Program Investigators' Workshop (HRP IWS). Galveston, TX. Jan. 28-31. [Poster]
- Colvard, A.; Ferrarezi, R. S. 2024. Designing & building a high-tech small-scale vertical farm for residences. *Proceedings.* 2024 AgTech Research and Extension for Emerging Undergraduates Program Presentation, Jul 25th, 2024. Athens/GA, USA.
- Feng, X., & Jia, X. (2024). NCERA101: Controlled Environment Technology and Use Station Report 2024 of North Dakota State University. NCERA 101 Annual Meeting, Des Moines, IA. March 23-26, 2024.
- Feng, X., & Jia, X. (2024). North Dakota State University CEA report. NE 2335 Resource Optimization in Controlled Environment Agriculture Annual Meeting, Honolulu, HI, September 23, 2024.
- Finnell, N.; Ferrarezi, R. S. 2024. Developing low-cost residential vertical gardening system. *Proceedings.* 2024 AgTech Research and Extension for Emerging Undergraduates Program Presentation, Jul 25th, 2024. Athens/GA, USA.
- Genhua Niu, Qianwen Zhang, and Jun Liu. Biostimulants improved onion seedling and mini-bulb growth. Texas Organic Farmers and Gardeners Association Conference, January 27, Pflugerville, Texas.
- Genhua Niu. Biostimulants can improve organic vegetable seedling growth. American Society for Horticultural Science, Horticultural Plant Reproductive Biology Interest Group Webinar, March 4, 2025.
- Housley, M. J.; Malladi, A.; Lessl, J.; Buel, R.; Ferrarezi, R. S. 2024. Enhancing monoterpene indole alkaloid production in *Catharanthus roseus* through controlled

environment cultivation and hormone applications. *HortScience* 59(9): S404 (Abstr.). 2024 ASHS Annual Conference, Sep 25th, 2024. Honolulu/HI, USA.

- Howell, E.; Housley, M. J.; Ferrarezi, R. S. 2024. Hydroponic system comparison for *Catharanthus roseus* production for extraction of biopharmaceutical secondary metabolites. *Proceedings.* 2024 AgTech Research and Extension for Emerging Undergraduates Program Presentation, Jul 25th, 2024. Athens/GA, USA.
- Imberti, David. 2024. Balancing *for Success: Optimizing CO2, Light, and Temperature.* Indoor Ag Con, Las Vegas, U.S. March 11.
- Jannatul F. P., Dey, S. M., & Feng, X. (2024). Performance Evaluation of a Robust Chip-Based RF Sensor for Greenhouses Soil Moisture Determination. American Society of Horticultural Sciences Annual Conference, Honolulu, HI. September 23-27, 2024.
- Jeong, Sangjun, Genhua Niu, Shuyang Zhen. Blue and green light and temperature interactively regulate growth, morphology, physiology and phytochemicals of lettuce. ASHS, Hawaii, Sept 23-27, 2024.
- Jeong, Sangjun, Genhua Niu, Shuyang Zhen. Light intensity regulates the interactive effects between far-red light and temperature on lettuce growth, morphology, photosynthesis, and secondary metabolite. ASHS, Hawaii, Sept 23-27, 2024.
- Jeong, Sangjun, Genhua Niu, Shuyang Zhen. Light Intensity Regulates the Interactive Effects between Far-red and Temperature on Lettuce Growth, Morphology, Photosynthesis, and Secondary Metabolite. The X International Symposium on Light in Horticulture, Seoul, Korea, May 19-22, 2024.
- Jia, X. (2024). Water quality impact on hydroponic lettuce production. University of Wyoming Controlled Environment Ag Workshop. Laramie, WY. April 23-25, 2024.
- Kang, S. and S. Zhen, 2024. Interactive effects between far-red photons and orange or red photons on growth, morphology, and fruit yield of dwarf tomatoes. Annual Conference of the American Society for Horticultural Science (ASHS). Honolulu, HI. Sept. 23-27.
- Kashif, M.; Ahamed, M. S. (2024). Potential of Climate-Smart PV Shade Screen Impact on Greenhouse Thermal Loads. ASABE Annual Meeting 2024, July 28-31, Anaheim, California.
- Kashyap, R. (2024). Forging Collaborative Solutions: Plant Disease Management in Urban & Controlled Environments, August 21, 2024, NE ANR Update, Oconee County.
- Kashyap, R. (2024). Integrated Pathogen Management in Urban & Controlled Agriculture: A Research and Extension Initiative, October 16, 2024. CEA Growers Day - Griffin.
- Kashyap, R. (2024). Integrated Plant Disease Management Solutions for Georgia's Urban and Controlled Agriculture, December 11, 2024. NW ANR update, Spalding County.
- Kashyap, R. (2024). Navigating Plant Disease Challenges in Urban & CEA Systems. In Urban Ecology Seminar Series, University of Tennessee at Chattanooga. October 11, 2024 *(Invited)*
- Kashyap, R. (2025). Tackling Plant Diseases in Urban and Controlled Environments: Integrated Approaches. Green GTBOP Webinar Series. March 13. 2025.
- Katende, A. Ayipio, E., Lukwesa, D., and D.E. Wells. 2024. Split-root hydroponics: investigating cherry tomato resilience to salinity stress. Presented at Aquaculture America 2024. February 18-21, 2024. San Antonio, TX. https://wasblobstorage.blob.core.windows.net/meeting-abstracts/AA2024AbstractBook.pdf

- Katende, A. Lukwesa, D. Bender, G., Smith, M.R., and D.E. Wells. 2024. Substrate combinations for reduced perlite reliance in tomato cultivation. HortScience 59(2) supplemental: SR63. Presented at the 2024 Annual Meeting of the Southern Region of ASHS. February 2-4, 2024.
- Katende, A., Lukwesa, D., Ayipio, E. and D.E. Wells. 2024. Split-root hydroponics: investigating cherry tomato resilience to salinity stress. HortScience 59(2) supplemental: SR12. Presented at the 2024 Annual Meeting of the Southern Region of ASHS. February 2-4, 2024.
- Khan, Md Noor E Azam, Joseph Masabni, and Genhua Niu. Optimizing hydroponic spinach cultivation in warm climates: effects of root zone cooling on growth and biochemical properties. Southern region ASHS. Grapevine, TX, February 1-2, 2025.
- Kobayashi, K. 2025. Controlled Environment Agriculture and Protected Cultivation. Presented at the CTAHR Conference, University of Hawaii at Manoa, Honolulu, HI. April 10, 2025.
- Kobayashi, K. 2025. TPSS 300 Tropical Production Systems: The Course on the Edge of Forever. Presented at the CTAHR Conference, University of Hawaii at Manoa, Honolulu, HI. April 11, 2025.
- Kurasaki, R. and K. Kobayashi. 2025. Controlled Environment Agriculture for Hawai'i's Climate. Presented at the CTAHR Conference, University of Hawaii at Manoa, Honolulu, HI. April 11, 2025.
- Lariscy, E.; Housley, M. J.; Ferrarezi, R. S. 2024. Light intensity and composition for production of *Catharanthus roseus* in vertical farms as a source of biopharmaceuticals. *Proceedings.* 2024 AgTech Research and Extension for Emerging Undergraduates Program Presentation, Jul 25th, 2024. Athens/GA, USA.
- Li, Z; Karimzadeh, S.; Ahamed, M. S. (2024). Detection of Calcium Deficiency in the Growing Stage of Lettuce Using Computer Vision. ASABE Annual Meeting 2024, July 28-31, Anaheim, California.
- Liu, Jun and Genhua Niu. 2025. Organic watermelon seedling production under controlled environment. Texas Organic Farmers and Gardeners Association Conference, January 27, Pflugerville, Texas.
- Liu, Jun, Joseph Masabni, and Genhua Niu. Beyond the label: Implications on fertilization management of organic watermelon transplant production. Southern region ASHS. Grapevine, TX, February 1-2, 2025.
- Liu, Jun, Joseph Masabni, and Genhua Niu. Combat root zone stresses organic hydroponics. Southern region ASHS. Grapevine, TX, February 1-2, 2025.
- Locatelli, S.; Nicoletto, C.; Zanin, G.; Sambo, P.; Ferrarezi, R. S. 2024. Resistenza allo stress termico in piantine da vivaio tramite inoculo di funghi endofiti. *Proceedings.* II Convegno Nazionale di Orticoltura e Floricoltura. Jun 19th, 2024. Padova/Emilia Romana, Italy.
- Lukwesa, D., Katende, A., Ayipio, E., and D.E. Wells. 2024. Evaluation of split-root system in shrimp effluent-based saline aquaponics for managing salinity stress in red kale ('KX-1') Brassica napus L. var Paularia. Presented at Aquaculture America 2024. February 18-21, 2024. San Antonio, TX. https://wasblobstorage.blob.core.windows.net/meeting-abstracts/AA2024AbstractBook.pdf

- Lukwesa, D., Katende, A., Wells, D.E., and E. Ayipio. 2024. Evaluating split-root system in shrimp effluent-based saline aquaponics for managing salinity stress in red kale ('KX-1') (Brassica napus L. var. Pabularia). HortScience 59(2) supplemental: SR11. Presented at the 2024 Annual Meeting of the Southern Region of ASHS. February 2-4, 2024.
- Lukwesa, D., Lopez, J., Oyedele, R., Bartley, P., and D.E. Wells. 2024. Evaluating the combined effects of gypsum and split-root system on cherry tomatoes (Solanum lycopersicum var. cerasiforme) and red kale (Brassica napus L. var Pabularia 'KX-1') salinity tolerance threshold. HortScience 59(2) supplemental: SR63. Presented at the 2024 Annual Meeting of the Southern Region of ASHS. February 2-4, 2024.
- Majeed, Yaqoob, and Azlan Zahid. 2024. "Deep Learning-Based Plant Spacing Estimation for Efficient Resources Utilization in Controlled Environment Agriculture." American Society of Agricultural and Biological Engineers (ASABE), July 27-31, 2024.
- Majeed, Yaqoob, and Azlan Zahid. 2024. "Quality Index Measurement System for Tomatoes Based on Self-Attention Convolutional Neural Networks and Channel Pruning and Quantization." AI in Agriculture Conference, April 15-17, 2024.
- McElhannon, D.; Nam, S.; Ferrarezi, R. S. 2024. Reducing energy costs in greenhouse supplemental lighting for basil production using "daily light integral carry-over" method. *Proceedings.* 2024 UGA CAES Young Scholars Program Presentation, Jul 12th, 2024. Athens/GA, USA.
- Meng, Q.* and S. Msabila. 2024. An intermediate calcium-mobilizing biostimulant concentration controls tipburn of two greenhouse hydroponic lettuce cultivars without affecting growth (abstr). HortScience 59(9S):S237. [oral]
- Meng, Q.* and T. Kramer. 2024. Increasing the nighttime lighting duration can hasten flowering of long-day plants (abstr). HortScience 59(9S):S462. [oral]
- Nam, S.; Yelton, M..; Haidekker, M.; Bastos, L. M.; Nambeesan, S.; van Iersel, M. W.; Ferrarezi, R. S. 2024. Adjusting supplemental LED light intensities based on real-time chlorophyll fluorescence measurements in a greenhouse. *HortScience* 59(9): S332-S333 (Abstr.). 2024 ASHS Annual Conference, Sep 25th, 2024. Honolulu/HI, USA.
- Nam, S.; Yelton, M..; Haidekker, M.; Bastos, L. M.; Nambeesan, S.; van Iersel, M. W.; Ferrarezi, R. S. 2024. Controlling supplemental LED light intensities using a chlorophyll fluorescence-based biofeedback system in greenhouses. *Proceedings.* 2024 ISHS Light Symposium, May 10th, 2024. Seul, South Korea.
- Nam, S.; Yelton, M.; van Iersel, M. W.; Ferrarezi, R. S. 2024. Energy efficient supplemental lighting control using chlorophyll fluorescence. *Proceedings.* 2024 Auburn University Graduate Student Symposium, Apr 10th, 2024. Auburn/AL, USA.
- Nieters, C. E.; Malladi, A.; Fisher, P. R.; Furlani, P. R.; Ferrarezi, R. S. 2024. Impact of light intensity on selecting optimal hydroponic nutrient solution management strategies in controlled environments. *Proceedings.* 2024 CEA Workshop Presented by Plenty & the University of Wyoming, Apr 24th, 2024. Laramie/WY, USA.
- Ojo, Mike, and Azlan Zahid. 2024. "Enhancing Crop Health: An Embedded Edge AI Solution for Real-Time Disease Detection." AI in Agriculture Conference, April 15-17, 2024.
- Ojo, Mike, and Azlan Zahid. 2024. "Leveraging Deep Learning for Multi-Step-Ahead Greenhouse Microclimate Prediction." American Society of Agricultural and Biological Engineers (ASABE), July 27-31, 2024.

- Padeniya, U., Lukwesa, D., Davis, D.A., Wells, D.E., and T.J. Bruce. 2024. Evaluating the influence of dietary immunostimulants on growth in Nile tilapia (Oreochromis niloticus) and romaine lettuce (Lactuca sativa) in a biofloc-integrated aquaponics system. Presented at Aquaculture America 2024. February 18-21, 2024. San Antonio, TX. https://wasblobstorage.blob.core.windows.net/meeting-abstracts/AA2024AbstractBook.pdf
- Pandey, S.; Ogden, A.B. Exploring the Role of Grafting in Enhancing Cold Tolerance in Cucumber: A Transcriptomics Perspective. *Proceedings.* 2025 Southern Region American Society for Horticultural Science, Feb 3rd, 2025. Las Colinas/TX, USA.
- Pennington, M., Fain, G., Gamble, A., Pickens, J., and D. Wells. 2024. Effects of combining controlled release fertilizer and organic matter on nutrient retention in green roof media. HortScience 59(2) supplemental: SR8. Presented at the 2024 Annual Meeting of the Southern Region of ASHS. February 2-4, 2024.
- Peterson, B. J.; Burnett, S. E.; Hutchinson, J.; Ferrarezi, R. S.; Peterson, A. J. 2024. Arduino Uno can reliably log substrate moisture from a bus of digital sensors and control a drip-irrigation system. *HortScience* 59(9): S217 (Abstr.). 2024 ASHS Annual Conference, Sep 25th, 2024. Honolulu/HI, USA.
- Phan, P.; Housley, M. J.; Ferrarezi, R. S. 2024. Designing and building a high-tech small-scale vertical farm for residences. *Proceedings.* 2024 AgTech Research and Extension for Emerging Undergraduates Program Presentation, Jul 25th, 2024. Athens/GA, USA.
- Qin, K.; Ferrarezi, R. S. 2024. Adjusting dissolved oxygen using an ozone generator in nutrient solution for optimized kale and arugula growth in hydroponics. *HortScience* 59(9): S512 (Abstr.). 2024 ASHS Annual Conference, Sep 25th, 2024. Honolulu/HI, USA.
- Rahman, M. H., & Rehman, T. U. (2023). Assessing the salt stress tolerance of Kale plants grown in aquaponics system via spatial and spectral predictive regression models. *American Society of Agricultural and Biological Engineers Annual International Meeting*, July 9-12, Marriott Anaheim – Omaha, Nebraska.
- Rahman, M. H., & Rehman, T. U. (2024). Assessing Salt Stress Tolerance in Kale Plants Grown in an Aquaponics Environment Using a High-Throughput Phenotyping System. *American Society of Agricultural and Biological Engineers Annual International Meeting*, July 28-31, Marriott Anaheim – Anaheim, CA.
- Rahman, M. H., Rehman, T. U., Busby, S., Ru, S., & Sanz Saez de Jauregui, A. (2024). Drought Tolerance Assessment with Statistical and Deep Learning Models on Hyperspectral Images for High-throughput Plant Phenotyping. *International Conference on Precision Agriculture*, July 21-24, Manhattan, Kansas, USA.
- Rauf, H.; Jackson, D.; Lessl, J.; Puebla, M. A.; Staha, J.; Toma, C.; Ames, Z. R.; Coolong, T.; Ferrarezi, R. S. 2024. Optimizing sampling methods for sap extraction to enhance plant nutrient analysis in CEA. *HortScience* 59(9): S238 (Abstr.). 2024 ASHS Annual Conference, Sep 25th, 2024. Honolulu/HI, USA.
- Reyes, J., & Kashyap, R. (2025). Vegetable Disease Management under CEA. In Southeast Regional Fruit and Vegetable Conference 2025. January 2025, Savannah.
- Rodrigues, C. Invited speaker “Food Safety for Indoor Agriculture” at the Alabama Fruit and Vegetable Growers Association Meeting, Gulf Shores, AL, 2024.
- Rodrigues, C. Invited speaker “Mitigating Food Safety Hazards in Controlled Environment Agriculture” at the 22nd Southeast Regional Fruit and Vegetable Conference, Savannah, GA, 2024.

- Rodrigues, C. Mickos, V., Blanchard, C., and D. Wells. 2024. Bacteriophage as an alternative method to control Salmonella enterica in water-recirculated systems for lettuce production. HortScience 59(9):S127 – Presented at the 2024 ASHS Annual Conference. September 23-27, 2024. Honolulu, HI.
- Rodrigues, C., Blanchard, C., Trandel-Hayse, M., Wells, D., Rehman, T. Post-harvest strategies to improve shelf-life of indoor-grown lettuce. V International Conference on Fresh-Cut Produce: Maintaining Quality and Safety, Foggia, Italy, 2024.
- Rodrigues, C., Mickos, V., Blanchard, C., Wells, D. Controlling *Salmonella enterica* in Water Recirculating Systems for Lettuce Production using a Bacteriophage Cocktail. IAFP Annual Meeting, Long Beach, CA, 2024.
- Sandoval, E.T., Blanchard, C., Trandel, M., da Silva, A.L.B.R., Rodrigues, C. Controlling *Salmonella enterica* in Roots of Indoor-Grown Lettuces. IAFP Annual Meeting, Long Beach, CA, 2024.
- Schoeller E. N. 2024. Advancing CEA Integrated Pest Management: A Rapidly Growing Industry. Entomological Society of America National Meeting. (*oral presentation*).
- Schoeller E. N. 2024. Enhancing Biological Control with Banker Plants and Supplemental Foods. Michigan Greenhouse Growers EXPO. (*oral presentation*).
- Schoeller E. N. 2024. *Thrips parvispinus*: A Looming Threat to Horticultural Production. Michigan Greenhouse Growers EXPO. (*oral presentation*).
- Schoeller E. N. 2025. Integrated Pest Management in Controlled Environment Vegetables. Southeast Regional Fruit & Vegetable Conference. (*oral presentation*).
- Schoeller E. N. 2025. Management of Fungus Gnats and Shore Flies in Protected Agriculture. Environmental Protection Agency IPM Webinar. (*oral presentation*).
- Schoeller E. N. 2025. The Invasive Pepper Thrips: What Do We Know and What's at Stake? Growing Wisconsin Conference. (*oral presentation*).
- Schoeller E. N., A. Wright, ML Lewis Ivey, J. Marlier 2024. Effective Insect Pest and Plant Pathogen Management in Controlled Environment Agriculture. Controlled Environment Agriculture Summit East. (*panel oral presentation*).
- Schoeller E. N., Fields A, Seals C 2025. Mastering Integrated Pest Management: Best Practices for CEA Success. Indoor Agcon. (*panel oral presentation*).
- Schoeller, E. N. 2024. *Franklinothrips vespiformis*: A Promising Biocontrol Agent for Whiteflies and Other Pests of Southeastern Greenhouses. Entomological Society of America Southeastern Branch Meeting. (*oral presentation*).
- Schoeller, E. N. 2024. Integrated Pest Management within Controlled Environments. Southeast Small Farm Business Training Conference. (*oral presentation*).
- Schoeller, E. N., P. Yu, S.V. Joseph, and M.T. Martin. 2024 *Thrips parvispinus*: Managing the Threat Panel. Southeast Green. Georgia Green Industry Association. (*panel oral presentation*).
- Speck, A., Jia, X., & Feng, X. (2024). Hydroponic lettuce growth under different pH levels. ND Controlled Environment Agriculture Conference, Fargo, ND, September 18, 2024.
- Speck, A., Jia, X., and Feng, X. (2024). The effect of high pH on hydroponic lettuce in an indoor environment. American Society of Horticultural Sciences Annual Meeting, Honolulu, HI, September 23-27, 2024.

- Subedi, B. S.; Ferrarezi, R. S.; Pandey, S.; Ogden, A. 2025. Response of three parthenocarpic zucchini cultivars to different substrates in greenhouses. *Proceedings.* 2025 Southern Region American Society for Horticultural Science, Feb 3rd, 2025. Las Colinas/TX, USA.
- Subedi, B. S.; Ferrarezi, R. S.; Pandey, S.; Ogden, A. B. 2025. Response of three parthenocarpic zucchini cultivars to different substrates in greenhouses. *Proceedings.* 2025 Southern Region American Society for Horticultural Science, Feb 3rd, 2025. Las Colinas/TX, USA.
- Syed, S.; Ahamed, M. S (2024): Hybrid Model for Forecasting Lettuce Yield in Indoor Vertical Farming. ASHS Annual Meeting, September 27, 2024, Honolulu, Hawaii.
- Thompson, B.; Housley, M. J.; Qin, K.; Ferrarezi, R. S. 2024. Enhancing rose propagation using moisture sensor-controlled irrigation and LED supplemental lighting in greenhouses. *Proceedings.* 2024 AgTech Research and Extension for Emerging Undergraduates Program Presentation, Jul 25th, 2024. Athens/GA, USA.
- Thompson, B.; Housley, M. J.; Qin, K.; Huber, A. C.; James, K.; Heavern, B.; Jensen, L.; Ferrarezi, R. S. 2024. Enhancing rose propagation using moisture sensor-controlled irrigation and LED supplemental lighting in greenhouses. *HortScience* 59(9): S190-S191 (Abstr.). 2024 ASHS Annual Conference, Sep 25th, 2024. Honolulu/HI, USA.
- Towner, M.; Rauf, H.; Ferrarezi, R. S. 2024. Evaluating growth responses of different lettuce cultivars under varying nutrient sufficiency ranges for sap analysis recommendations. *Proceedings.* 2024 UGA CAES Rising and Emerging Scholars Program Presentation, Jul 18th, 2024. Athens/GA, USA.
- Trandel-Hayse, M., Blanchard, C., Wells, D., Rehman, T., Rahman, Md, and C. Rodrigues. 2024. Postharvest quality and shelf-life of living lettuce: should growers keep or cut the roots? HortScience 59(2) supplemental: SR37. Presented at the 2024 Annual Meeting of the Southern Region of ASHS. February 2-4, 2024.
- Trandel-Hayse, M., Wells, D., Rehman, T., Blanchard, C., Rodrigues, C., and MD Rahman. 2024. Nutritional quality and shelf-life of "living lettuce" through 28 days of cold storage. HortScience 59(9):S174 – Presented at the 2024 ASHS Annual Conference. September 23-27, 2024. Honolulu, HI.
- Vieira, G. H. S.; Ferrarezi, R. S. 2024. Assessing water status in citrus plants using thermal imaging in greenhouses. *HortScience* 59(9): S184-S185 (Abstr.). 2024 ASHS Annual Conference, Sep 25th, 2024. Honolulu/HI, USA.
- Volz, T., Rodrigues, C., Dunn, L.L., Jackson-Davis, A., Ferrarezi, R.S. Bridging the Gap: A Comprehensive Needs Assessment Survey to Identify Food Safety Knowledge Gaps Among Indoor Growers in the United States. Southern Region American Society of Horticultural Science, Atlanta, GA, 2024.
- Zahid, Azlan, and Yaqoob Majeed. 2024. "Utilizing Deep Learning for Hydroponic NFT Channel Spacing Optimization." American Society of Horticultural Sciences, Hawaii, Sept 23-27, 2024.
- Zahid, Azlan. "AI-Enabled Sensing and Automation for Controlled Environment Agriculture." 2024 NTU-TAMU Bilateral Symposium on Sustainable Agriculture, Taipei Taiwan, Nov 12-14, 2024.
- Zahid, Azlan. "AI-Enhanced Computer Vision for Crop Monitoring in Controlled Environment Agriculture." American Society of Horticultural Sciences; Colloquium on AI in Horticulture, Hawaii, Sept 23-27, 2024.

- Zahid, Azlan. 2024. "AI-Enhanced Computer Vision for Crop Monitoring in Controlled Environment Agriculture." Ohio State University Controlled Environment Agriculture Conference, Columbus, July 15, 2024.
- Zahid, Azlan. 2024. "Potential of Computer Vision for Crop Monitoring in Controlled Environment Agriculture." Controlled Environment Conference University of Wyoming, April 23-25, 2024.
- Zhang, Qianwen, Joseph Masabni, Genhua Niu. Biostimulants promoted onion seedling growth and helped mitigate drought stress. ASHS, Hawaii, Sept 23-27, 2024.
- Zhen. 2024. Optimizing nutrient-rich food production in controlled environments: from greenhouses and indoor farms to space agriculture. Texas Plant Protection conference (TPPA). College Station, TX.
- Zhen. 2025. The Role of Far-red Photons in Photosynthesis and Crop Lighting in Controlled Environment Agriculture. Molecular Plant Sciences Seminar Series. Michigan State University. East Lansing, MI 03/17/2025
- Zook S, Claypool DA, Chen J, and Jabbour R. 2024. Growth and physiology of three buckwheat cultivars under reduced substrate water contents. 2024 ASHS Annual Meeting, Honolulu, Hawaii. https://ashs.org/page/conferenceprogram [Poster]

5.F. Extension/trade magazine articles

- Allred, J. and N. Mattson. 2024. Dialing in microgreens production. Produce Grower Magazine. (December).
- Fogarty, S., Newbold, E., Dunn, L., Rodrigues, C., Calatena, R., Bihn, E., George, L., Machado, R., Sirsat, S., Callahan, C. Glossary of Aquaponic and Hydroponic Produce Safety Terms. National Food Safety Clearinghouse at the University of Vermont, 2025. Available at: https://foodsafetyclearinghouse.org/resources/glossary-aquaponic-and-hydroponic-produce-safety-terms.
- Hollick, J. and C. Kubota. 2024. How to grow grafted watermelon transplants. eGro Edible Alerts. Vol 9.1 https://www.e-gro.org/pdf/e901.pdf
- Karall, J. and N. Mattson. 2024. Do microgreens respond to daily light integral and carbon dioxide enrichment? E-Gro Edible Alert 9(4). pp. 6. https://e-gro.org/pdf/e904.pdf
- Karall, J. and N. Mattson. 2024. Do microgreens respond to fertilizer concentration and substrate depth? E-Gro Edible Alert 9(6). pp. 6. https://e-gro.org/pdf/e906.pdf
- Kubota, C. 2024. UV radiation transmission of common greenhouse glazing materials. eGro Edible Alerts. Vol 9.9 https://www.e-gro.org/pdf/e909.pdf
- Marie, T. R., Leonardos, E. D., & Grodzinski, B. (2024) Using Whole-Plant Diurnal Transpiration and Remotely Sensed Thermal Indices to Phenotype Circadian Rhythm Traits. In Handbook of Photosynthesis. Editor; Pessarklia, M. Chapter 25: pp. 498-509. CRC Press, Boca Raton, Fl., USA14. Lopez, R.G. 2023. Photoperiod management-Flower induction of specialty cut flowers. Greenhouse Product News 33(10): 6–8.
- Mattson, N. 2024. CEA is growing: Trends from the U.S. 2022 census of agriculture. E-Gro Edible Alert 9(3). pp. 5. https://e-gro.org/pdf/e903.pdf
- Mattson, N. 2025. Square foot weeks: quantify space-use efficiency for greens and herbs. E-Gro Edible Alert 10(3). pp. 6. https://e-gro.org/pdf/e1003.pdf
- Meng, Q. 2025. Combatting lettuce tipburn with a biostimulant. Inside Grower 2:32–33.

- Tran, K., A.J. Both, and C. Kubota. 2024. A primer of artificial intelligence for greenhouse control. eGro Edible Alerts. Vol 9.8 https://www.e-gro.org/pdf/e908.pdf

5.G. Theses/dissertations

- Abir Ahsan (2024): Resource Use and Environmental Impacts of Stand-alone Geothermal Heat Pumps for Greenhouse Climate Control. MS Thesis. (Supervised, Shamim Ahamed)
- Brockett, R. 2023. Ostrich Fern Fiddlehead (*Matteuccia struthiopteris* L. Todaro) Cultivation: Controlled Environment Requirements and Growth Cycle Compression. MSc. School of Environmental Sciences, University of Guelph, Guelph, Ontario
- Omar Samara (2024). Evaluation of Agrivoltaic Systems for Enhanced Agricultural Resource Sustainability. PhD Thesis. (Co-Supervised, Shamim Ahamed)
- Progga, J.F. 2025. Innovative strategies for controlled environment agriculture: enhancing RF sensing of soil moisture using machine learning and evaluating bio-media performance in hydroponic production. M.S. thesis, Fargo, North Dakota: North Dakota State University, Department of Agricultural and Biosystems Engineering.
- Silver, J. 2025. Application of an Algae-based Biopolymer in Deep Water Culture of Lettuce (Lactuca sativa). MSc. School of Environmental Sciences, University of Guelph, Guelph, Ontario
- Speck, A. 2024. Effect of pH levels on the marketability of hydroponic lettuce. M.S. thesis, Fargo, North Dakota: North Dakota State University, Department of Agricultural and Biosystems Engineering.
- Stoochnoff, J. 2023. Lighting for Bush Bean (Phaseolus vulgaris) Production in a Controlled Environment. PhD. School of Environmental Sciences, University of Guelph, Guelph, Ontario
- Terlizzese, D. 2024. Characterizing and Improving the Light Environment in Greenhouse Fruiting Vegetable Crops. MSc. School of Environmental Sciences, University of Guelph, Guelph, Ontario
- Wake, M. 2024. Refining Environmental Parameters for Wheat (Triticum aestivum L.) Production in Vertical Farms. MSc. School of Environmental Sciences, University of Guelph, Guelph, Ontario
- Xia, J. 2024. Evaluating the photomorphogenetic and molecular response of petunia to far-red radiation and daily light integral, and modeling horticultural strategies for enhancing plant factory profitability. PhD Dissertation. Cornell University. 337 pp.

5.H. Popular articles

- Christopher, Mark. 2024. "Testing." *Percival-Scientific, Inc.* November 25. percival-scientific.com/wp-content/uploads/2024/12/105-White-Paper-High-Standard-for-Testing-112524-FNL.pdf.
- Greenhouse Product News. Interview with Madi Schafer, “UGA’s Erich Schoeller discusses thrips threats and boosting biological control at the Great Lakes EXPO”. Published on November 10, 2024. (Interview URL)
- Imberti, David. 2024. "LED Spectra in Plant Growth." *Produce Grower.*
- Martinez-Espinoza, A., Kashyap, R., & Hibbs, G. (2024). Spring dead spot diagnosis and management: Fall is the time to act.

https://site.caes.uga.edu/entomologyresearch/2024/10/spring-dead-spot-diagnosis-and-management-fall-is-the-tine-to-act/

- Percival-Scientific, Inc. 2024. "Reducing Condensation in Tissue Culture (CU) Chambers." *Percival-Scientific, Inc.* February 26. percival-scientific.com/wp-content/uploads/2025/02/105-White-Paper-Reducing-Condensation-in-Tissue-Culture-Chambers-022625-FNL.pdf.
- Produce Grower Magazine. Interview with Kelli Rodda, “Questions with Erich Schoeller”. Published on January 29, 2025. (Interview URL)
- *Resource.* 2025. "ASABE AE50 Outstanding Innovations AWARD." Jan. and Feb.: 12.

5.I. Patents

- Imberti, Henry, David Imberti, and Daniel Kiekhaefer. 2024. Environment Controlled Chamber with IR Condensation Reduction. Patent US 2025/0002833. May 21.