2024 NCERA-101 Committee on Controlled Environment Technology and Use

Station Report: North Dakota State University Agriculture Experiment Station

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1. New Facilities and Equipment

- North Dakota State University (NDSU) established two new Controlled Environment Agriculture (CEA) laboratory space (540 ft²) within the pilot plant. The facility includes six heavy-duty growing racks, each with dual shelves outfitted with LED lighting, and continuous monitoring of environmental parameters such as temperature and humidity.
- A Conviron growth chamber was procured for leafy greens research, featuring additive humidity and CO_2 control and bypass dehumidification capabilities.
- Several NFT hydroponic systems and a fertroller system from CropKing have been ordered to support ongoing hydroponic and nutrient management studies.

2. Unique Plant Responses

- A greenhouse experiment evaluated the use of high-pH municipal tap water—typical in Fargo, ND—for hydroponic lettuce production, with the goal of determining if minimal adjustments could maintain acceptable yield and quality.
- A growth chamber study tested two novel bio-based substrates, derived from soy and wheat, for their suitability in hydroponic lettuce production.
- An RF sensor prototype was developed and calibrated using machine learning techniques to enhance the accuracy of soil moisture measurement for CEA applications.

3. Accomplishments Summaries

- *Hydroponic pH tolerance:* Lettuce yield did not significantly differ across a pH range of 6.3 to 8.3, though varietal differences were significant. These results offer practical guidance for small-scale growers to reduce pH adjustment costs.
- *Bio-Substrate evaluation:* While the bio-substrates yielded lower fresh shoot weight overall, matching specific substrates to varieties was found to significantly impact water use efficiency (WUE), emphasizing the need for substrate-variety optimization.
- *Sensor calibration with machine learning:* Calibration of a chip-based RF sensor using an artificial neural network improved the R^2 value from 0.44 (linear regression) to 0.72, demonstrating the utility of machine learning in enhancing sensor precision for soil moisture monitoring.

4. Impact Statements

- Water quality management: Demonstrating the feasibility of using high-pH municipal water in hydroponics without significant yield loss provides growers with cost-effective options and reduces dependence on chemical pH adjustment.
- Bio-substrate innovation: The performance differences between bio-substrates and commercial options highlight the importance of selecting compatible substrate-variety combinations to maximize WUE and productivity, supporting sustainable media development.

- Technology advancement: The integration of ML with RF sensing technology advances precision monitoring tools in controlled environments, contributing to more accurate irrigation management and resource optimization.
- Graduate training and workforce development: Two graduate students completed M.S. degrees focusing on CEA technologies and resource use optimization. Their work contributed to advancements in hydroponic water management and sensor development, and prepared them for careers in CEA innovation and sustainability.
- Outreach and stakeholder engagement: NDSU organized and hosted the first North Dakota Controlled Environment Agriculture Conference in 2024. The event convened a diverse group of participants, including representatives from USDA ARS, University of Minnesota, tribal colleges, and local producers and industry stakeholders. This gathering fostered regional collaboration, highlighted emerging research, and identified local priorities for advancing CEA technologies.

5. Published Written Works

Thesis/Dissertation:

1. 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.

2. 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.

Symposium Proceedings, Oral and Poster Presentation:

1. 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.
2. 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.
3. 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.
4. Speck, A., Jia, X., & Feng, X. (2024). Hydroponic lettuce growth under different pH levels. ND Controlled Environment Agriculture Conference, Fargo, ND, September 18, 2024.
5. Jia, X. (2024). Water quality impact on hydroponic lettuce production. University of Wyoming Controlled Environment Ag Workshop. Laramie, WY. April 23-25, 2024.
6. 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.