NCERA 101 Station Report – University of Minnesota

1. New Facilities and Equipment
    a. The University of Minnesota has completed approximately 50% of a re-lighting project at the Plant Growth Facility in St. Paul. Once complete, the project will have replaced 1,578 high pressure sodium lamps with LED lamps (VYPR 3x; Fluence Bioengineering, Austin, TX). Additionally, the University procured soft funds and purchased 17 new growth chambers (PGR 15; Conviron, Winnipeg, Canada) to replace aging and decommissioned chambers (E15; Conviron).
    b. The Eylands Controlled Environment Agriculture lab has purchased a equipment to enhance its ability to perform and publish scientific research:
        i. 36 quantum sensors with data loggers (PQ-610; Apogee Instruments, Logan, UT)
        ii. 36 temperature and relative humidity data loggers (HOBO UX100-003; Onset, Bourne, MA)
        iii. Chlorophyll fluorometer (mini-PAM II; Heinz Walz, Effeltrich, Germany)
        iv. Acquired a non-functional infra-gas analyzer (LI-6400 XT; LiCor, Lincoln, NE) and repaired to working conditions
2. Unique Plant Responses
    a. PhD students Chris Nieters (Hort) and Kristine Loh (Mech. Eng.) along with faculty members Nate Eylands (Hort) and Uwe Kortshagen (Mech. Eng.) developed computational models for lettuce plants in a greenhouse covered with silicon nanocrystal quantum dots (Si-NC QD). The models predicted enhanced biomass accumulation with an spectrum that is altered to provide more long-wavelength radiation. However, the reduced transmissivity predicted less biomass. The interaction between the two predicted increased biomass dependent upon latitude and daily light integral.
    b. Cannabis
3. Accomplishments
    a. Short-term Outcomes
        i. The University of Minnesota's Regional Sustainable Development Partnerships program procured funding to subsidize 50% of the building material and labor costs (approx. $50K) for five Minnesota growers adopting the Farmscale Deep Winter Greenhouse design for private commercial enterprise. Nate Eylands (UMN CEA professor)

was chosen as a panel member to select applicants to be awarded these subsidies. The greenhouses are currently under construction and should be growing plants destined for sale in their respective communities by mid-summer at the latest.

ii. Faculty members Nate Eylands (Hort) and Ce Yang (Bioeng.) and students Jordan Bergstrom (M.S.) and Ajalon Peterson (undergraduate) conducted an experiment to test the effects of channel length and nutrient deprivation in a nutrient film technique (NFT) hydroponic system. Basil plants were grown in NFT system with channels measuring 10, 25, and 40 ft. in length. Tissue analyses and hyperspectral imaging were carried out to quantify differences in nutrient accumulation of plants based on their distance from the fertigation emitter (top of the channel). No quantifiable differences were observed for plant yields or nutrient concentrations. These data indicate that length of NFT channel does not matter with regards to yield and nutrition of basil plants.

b. Outputs
    i. Nate Eylands (UMN) and collaborators published one peer-reviewed article on computational models that predict lettuce growth using luminescent solar concentrators. Supplementary data is available and held in a data repository to be used by the public.
    ii. Nate Eylands (UMN) and collaborators submitted two papers for peer-review publication regarding plasma-activated water (PAW). One that is a literature review of PAW in agriculture and the other that is a survey addressing CEA growers' willingness to buy or try PAW in their respective operations.
    iii.
    iv. published one peer-reviewed article that is a literature review of plasma-activated water in agriculture.
c. Activities
    i. Nathan Eylands (UMN) and M.Sc. student Jordan Bergstrom investigated the effects of plasma activated water on germination metrics of spinach (cv. 'Lizard') seeds after priming for set durational periods (0, 1, 3, 6, 12 h). Seeds primed in plasma activated water for 6 to 24 h exhibited higher germination percentage, rate, and uniformity over those equivalently primed using distilled water.

ii. Nathan Eylands (UMN) and undergraduate student Matthew Robidou investigated the effects of light intensity (100, 200, 300, 400 $\mu mol \cdot m^{-2} \cdot s^{-1}$) on cannabis rooting in a low-pressure aeroponic system. Cuttings rooted under 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ exhibited greater shoot and root growth. However, cuttings rooted under 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ contained more chlorophyll than the other treatments.

d. Milestones

i. The University of Minnesota is planning a short study to test the effects of three light management films incorporated on greenhouse glazing in collaboration with 3M. Control houses will be measured against film treated houses to quantify actual transmissivity, light quality effects, plant yield, leaf temperature, and atmospheric temperature.

4. Impact Statements

a. The use of Haber-Bosch derived nitrogen and synthetic chemicals in agriculture is creating environmental problems that, if left unchecked, may not be reversible. The University of Minnesota, Cornell University, and University of California Davis have conducted multiple studies on the application of plasma-activated water (PAW) in CEA. The primary constituents of PAW are water, atmospheric gas, and electricity which are all naturally occurring. This research group has shown how the unique chemistry of PAW can reduce two-spotted spider mite outbreaks, improve seed germination, and enhance seedling vigor in multiple crops.

5. Published Written Works

a. 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.

b. 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.

c. 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.