NCERA-101 Station Report – Texas A&M University

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(Activities below are only from the Dallas Center)

Accomplishment summary

- Heat tolerance of eight spinach cultivars was determined based on plant growth index, biomass, and chlorophyll fluorescence measurement (potential maximum quantum efficiency of photosystem II, F_v/F_m, and performance index, PI_{abs}). Plants were grown under three temperatures: 22, 26, and 32 ◦C. Among the eight cultivars, Lakeside, Lizard, Seaside and Red Tabby grew more uniformly and were better quality at harvest than Space, Mandolin, Kolibri, and Koiwa. Koiwa had the lowest germination percentage and bolted under 26 ◦C.
- For microgreen indoor production, replacing or adding UV-A and far-red (FR) light to white LED affected growth, morphology and phytochemicals. However, the magnitude of the effect is relatively small. Also, adding FR may reduce yield and some phytochemical concentrations. Therefore, considering the costs of LED lights with UV-A and FR spectrums, commonly available white LED lights are recommended for commercial production.
- Supplemental lighting (SL) is necessary to enhance growth and quality in greenhouse hydroponic leafy green production in Texas. We found that short-term SL with different commercial LED lights: UV-A and blue combination, red and blue LED, and full spectrum white LED are equally effective to significantly enhance the quality of leafy greens in terms of leaf thickness and greenness, antioxidant capacity, and concentrations of phytonutrients such as anthocyanins, carotenoids, and total phenolics; however, shoot fresh biomass and total leaf area were generally not affected by SL.
- Ph.D. graduate student Sangjun Jeong's research (supervised by Shuyang Zhen and Genhua Niu) indicated that FR light and temperature regimes interactively affect plant morphology, growth, and biomass in lettuce and basil. Also, the interaction between FR and temperature depends on light intensity/photoperiod.

- Biostimulants can improve onion seedling and early bulb growth. A study was conducted to determine the effects of nine microbial biostimulants on plant growth of three onion cultivars at both seedling and mini-bulb stage. Biostimulants did results in significant positive effects on shoot and root morphology or biomass, expect for a higher root to shoot dry weight ration compared to the control. At the mini-bulb stage, we observed that the microbial biostimulants MycoApply, Mighty Mycorrhizae, and Lalrise Bacillus increased plant height, while MycoApply, Mighty Mycorrhizae, and Tribus Continuum increased bulb diameter and bulb fresh weight when compared to the control. Our research showed promising results, however, much more research is needed to optimize the application rates and timing of these biostimulants.
- Producing organic vegetable seedlings under controlled environment is needed to support the growing organic industry. We compared the effects of three organic fertilizers (Sustane 4-6-4, Nature Safe 7-7-7, and Dramatic 2-4-1) at four application rates with conventional fertilizer with matching rates of nitrogen (N) on watermelon seedling growth and morphology. The best performance on aerial morphological characters was observed in the highest fertilization rates of control and Dramatic 2-4-1 treatments (0.84 g/L N). However, root performance showed different trends among fertilizers from aerial morphology of watermelon seedlings. Dramatic 2-4-1 treatments had the lowest root volume, while Sustane 4-6-4 had significantly increased total root length, root area, root surface area, and root tip number when compared to control and Dramatic 2-4-1 treatments. The best root performance was observed in the second highest rate (0.56 g/L N) of Sustane 4-6-4. Better root establishment in seedlings would ensure more competitive potential after transplanting.
- A deep learning model was developed to detect the bacterial wilt disease in greenhouse tomato crops. Over-amplification of the contrast due to uneven illumination is a major concern for color image-based disease detection systems. We used image enhancement algorithms to adjust the light and contrast in the images. A new deep learning approach was used to train the features on the plant leaves in the images to develop the disease prediction algorithm. The system achieved more than 90% accuracy, advocating its implementation for site-specific crop management systems, including robotic spraying and disease watchdog. Additionally, a systematic literature survey of AI applications in CEA was conducted and the results were published in a scientific journal. The survey highlighted the pros and cons of different AI model and techniques implemented for various tasks in CEA production.
- We hosted the 4th Annual Conference in urban horticulture – Controlled environment conference at the Dallas Center with about 100 participants.
- We hosted a stakeholder listening meeting ahead of the annual CEA conference, which is part of the planning SCRI grant on “Greenhouse Microenvironment Control for Hydroponic Leafy Greens in Hot and Humid Climate”.

Impact Statements

- The information on heat tolerant spinach cultivars can provide hydroponic growers to produce spinach in greenhouses in the southern region with extended growing season. Normally, spinach can't be grown in the long summer season even in the greenhouse. With root zone cooling and selection of heat tolerant cultivars, the growing season can be extended to early summer.
- Our results in supplemental lighting at the end-of-production can boost the quality, especially for red leaf lettuces, without significantly increasing production costs on supplemental lighting.
- Manual crop scouting is time-consuming and laborious, as well as the spatial variability of the disease severity in the field is overlooked. Thus, the detection of the disease symptoms and hotspot regions is essential to stop the spread to other plants. This is ongoing work; the benefits and impact can be quantified after the completion of the project. In the future, the deep learning models will be integrated into the edge devices and overhand gantry system for automatic scanning of crops that will allow growers to get an instantaneous report on the disease symptoms and frequency or severity of the issue. The management decisions considering the variability will result in chemical savings, reducing the production cost and enhancing the sustainability of the industry, thus contributing to the broader public benefits. Implementing this technology for smart or precision spraying will improve crop safety and reduce chemical usage, lowering production costs and environmental pollution due to excessive chemical applications, thus contributing to the broader public benefits.
- Our fourth controlled environment conference was held in December 2022 and was well received and attended by the industry.

Publications

Refereed journal articles

1. Hooks, T.; Sun, L.; Kong, Y.; Masabni, J.; Niu, G. Adding UVA and Far-Red Light to White LED Affects Growth, Morphology, and Phytochemicals of Indoor-Grown Microgreens. Sustainability 2022, 14, 8552. https://doi.org/10.3390/su14148552.
2. Hooks, T., L. Sun, Y. Kong, J. Masabni, and G. Niu. 2022. Effect of nutrient solution cooling in summer and heating in winter on the performance of baby leafy vegetables in deep-water hydroponic systems. Horticulturae 2022, 8, 749. https://doi.org/10.3390/horticulturae8080749.
3. Hooks, T., L. Sun, Y. Kong, J. Masabni, and G. Niu. 2022. Short-term pre-harvest supplemental lighting with different light emitting diodes improves greenhouse lettuce quality. Horticulturae 8, 435. Doi.org/10.3390/horticulturae8050435.

4. Hooks, T., J. Masabni, L. Sun, G. Niu. 2022. Effects of organic fertilizer with or without a microbial inoculant on the growth and quality of lettuce in an NFT hydroponic system. Technology in Horticulture 2, 1 doi: 10.48130/TIH-2022-0001.
5. Ojo, M. O., and Zahid, A. 2023. Improving deep learning classifiers performance via preprocessing and class imbalance approaches in a plant disease detection pipeline. Agronomy, 13, 887.
6. Ojo, M. O., and Zahid, A. 2022. Deep learning in controlled environment agriculture: A review of recent advancements, challenges, and prospects, Sensors 2022, 22(20), 7965.

Presentations

Jeong, S., G. Niu, and S. Zhen. Light intensity regulates interactive effects between far-red light and temperature on plant growth and morphology in lettuce and basil. Southern Region ASHS, Feb. 03-05, 2023, Oklahoma City, OK.

Jeong, S., G. Niu, and S. Zhen. 2022. The involvement of light intensity effects between far-red and temperature on plant growth and morphology. International Meeting on Controlled Environment Technology and Use, Arizona, Sept 11-14.

Jeong, S., G. Niu, S. Zhen. The interactive effects between far-red and temperature on plant growth and morphology: dependency of the predictive power of phytochrome photoequilibrium on temperature. Annual Conference of ASHS, Chicago, July 31 to Aug 3.

Kong, Y., J. Masabni, and G. Niu. 2023. Temperature and light spectrum affect lettuce and pak choy growth and morphology. Lone Star Hort Forum, College Station, Jan 9-11.

Ojo, M., Zahid, A. 2022. Automatic crop disease scouting system based on deep neural networks model. *In 2022 ASABE Annual International Meeting (Presentation)*

Zhang, Q., J. Masabni, and G. Niu. 2023. Organic fertilizer type and rate affect watermelon seedling production. Southern Region ASHS, Feb. 03-05, 2023, Oklahoma City, OK

Zhang, Q., J. Masabni, and G. Niu. 2023. Organic fertilizer type and rate affect watermelon seedling production. Lone Star Hort Forum, January 9, 2023, College Station, TX