Arizona State University 2021 Station Report
NCERA-101: Committee on Controlled Environment Technology & Use

Yujin Park and Zhihao Chen
College of Integrative Sciences and Arts, Mesa, AZ 85212

New Equipment and Facilities

- The Arizona State University (ASU) Indoor Farming Lab was launched in April, 2021. The ASU Indoor Farming Lab consists of 10 deep water culture hydroponic growing racks, each with three tiers. Each growing rack is equipped with LED lamps, a quantum sensor (LI-190R, LI-COR), and a thermocouple (Type E, Omega Engineering). Two additional fan aspirated air temperature and relative humidity probes (EE08-SS, Apogee) are used to monitor the air temperature and relative humidity in the ASU Indoor Farming Lab. All environmental data is recorded by a datalogger (CR1000X, Campbell Scientific).
- Multiparameters pH/EC/DO/Temperature (HI98194, Hannah Instruments) were purchased to measure the dissolved oxygen concentration of the hydroponic nutrient solution.
- Fan aspirated thermistors (TS-110-SS, Apogee), pyranometers (LI-200R, LI-COR), quantum sensors (LI-190R, LI-COR), and a datalogger (CR1000X, Campbell Scientific) were installed in the research greenhouse.
- Two walk-in growth chambers are installed. The growth chambers will enable experiments to investigate the effects of different temperatures, light qualities, CO_2, and relative humidity on plant growth and development.

Accomplishment Summaries

- **ASU Indoor Farming Certificate Program**: Yujin Park and Zhihao Chen are launching a new ASU certificate program 'Indoor Farming Certificate' from the 2022 Fall semester. As a part of the certificate program, Zhihao Chen launched the ABS 394 Future of Agriculture: Vertical Farming course in the 2021 Spring semester, and he will launch ABS 369 Hydroponic Food Crop Production course in the Fall 2022 semester.
- **Indoor Strawberries**: The influence of sole-source lighting was investigated on plant growth, flowering, and fruit development in ever-bearing strawberry 'Albion' in the vertical farm. Increasing photosynthetic photon flux density (PPFD) from 200 to 450 $\mu mol \cdot m^{-2} \cdot s^{-1}$ and photoperiod from 12 to 16 hours increased plant growth while extending photoperiod was more effective at accelerating flower and fruit development and increasing fruit yields than increasing PPFD.
- **Sustainable Fertilizers for Vertical Farming**: In collaboration with Homer Farms Inc., the effects of organic fertilizer derived from food waste were evaluated on indoor hydroponic leafy green production. At the same electrical conductivity (EC), food waste fertilizer provided 60% less total nitrogen than chemical fertilizer, and most nitrogen in the food waste fertilizer was in the form of ammonium (63%) and organic nitrogen (37%) while 80% of nitrogen in the chemical fertilizer was nitrate. Arugula and two lettuce cultivars were successfully grown with food waste fertilizer, but the arugula and lettuce plants grown with food waste fertilizer had 85-98% lower shoot fresh weight than those grown with chemical fertilizer. Other organic fertilizers, including fish products, are being tested for optimal plant growth in the Indoor Farming Lab as well.

- **Luminescent Greenhouse Film Applications**: In collaboration with UbiGro, the effects of using quantum dot luminescent greenhouse films were evaluated on greenhouse strawberry production. The spectral conversion using luminescent greenhouse films improved the strawberry fruit yield and quality under lower daily light integral conditions compared to transparent greenhouse film.
- **Greenhouse Industrial Hemp Transplants**: In collaboration with SMH Organic Family Farms, the effects of soil types and nutrient concentrations were investigated on the greenhouse industrial hemps transplant production. In three industrial hemp cultivars 'Frost Lime', 'RN13', and 'Serenity', the germination rate increased with silt loam than with sandy loam, and increasing EC of fertilizer up to 2.0 $mS \cdot cm^{-1}$ enhanced industrial hemp seedling growth regardless of soil types.

Impact Statements

- There are growing interests in vertical farming, urban farming, and greenhouse production in the Phoenix metropolitan area. For students and working professionals interested in controlled environment agriculture, the new ASU Indoor Farming certificate program will provide specific indoor crop production and management training. Students will gain marketable knowledge and skills that will enable them to prepare and advance their careers in the greenhouse and indoor vertical farming industry.
- The ASU Indoor Farming Lab is working with strategic partners from both private sectors (e.g., Homer Farms Inc.) and public sectors (e.g., Swette Center for Sustainable Food Systems) to build a more resilient food system in Arizona when Arizona is under Tier 1 Water Shortage.
- The effects of sole-source lighting were mostly studied in leafy vegetables and ornamental plants. We demonstrated the value of optimizing sole-source lighting conditions for enhancing indoor strawberry fruit yields.
- We demonstrated the possibility of using anaerobic digestate derived from food waste as sustainable alternatives to synthetic chemical fertilizer for growing leafy vegetables in the vertical farm to create a circular economy from food waste to food.
- Using a luminescent greenhouse film is a way to use sunlight more efficiently for crop production. We demonstrated the spectral changes by a luminescent greenhouse film can benefit greenhouse strawberry production under low light conditions.
- While industrial hemp is a high-value crop with many uses, including fiber, fuel, and food, Arizona growers face many challenges of growing industrial hemp, including poor seed germination and seedling establishment. We identified better soil and nutrient conditions to improve the germination and seedling establishment for local industrial hemp growers.

Published Written Works

Research Abstracts

1. Cherry, H., K. Davis, Z. Chen, C.R. Penton, and Y. Park. 2021. Characterizing plant growth and microbiome community under a sustainable food waste fertilizer in hydroponics. ASA, CSSA and SSSA International Annual Meetings
2. Mcclintic, N. and Y. Park. 2021. Effects of food waste fertilizer application and soil types on seedling growth of three industrial hemp cultivars. ASA, CSSA and SSSA International Annual Meetings
3. Park, Y., J. Collins, D. Herbert, and M.R. Bergen. 2021. Effects of a QD luminescent

greenhouse film on the plant growth and fruit quality of greenhouse strawberry. J. Amer. Soc. Hort. Sci.
4. Park, Y. and R. Sethi. 2021. Effects of photoperiod and photosynthetic photon flux density of sole-source lighting on indoor strawberry production. J. Amer. Soc. Hort. Sci.