2018 Purdue NCERA-101 Station Report

The Department of Horticulture & Landscape architecture at Purdue University welcomed Nathan Deppe as Plant Growth Facilities Manager beginning September 18, 2017. Nathan has 15 years experience previously managing CEA research facilities, including growth rooms, chambers, and greenhouses, first at the ARS National Center for Agricultural Utilization Research at Peoria, Illinois, then as Plant Care Facilities Manager of the greenhouse/growth-chamber complex dedicated to plant breeding at the University of Illinois, Urbana-Champaign. At Purdue, Nathan is promoting establishment of new technologies for cutting-edge research and education.

Hye-Ji Kim Lab Report for 2018

1. **New Facilities and Equipment** n/a
2. **Unique Plant Responses:** Dr. Kim's group has investigated the effects of light source and quality on tomato growth and yield and discovered that far-red light enhanced plant growth and yield of greenhouse tomato via changes in physiological mechanisms (water relations and biomass allocation patterns) leading to earlier crop production and higher yield. Dr. Kim's group also found that far-red-light grown tomatoes have better flavor (greater aroma, texture, and sweetness) compared to high pressure sodium (HPS)-lamp-grown tomatoes. Ion analyses revealed that tomato fruits under far-red light are meaty and contain greater total soluble salts (TSS), and accumulate higher amounts of sodium and sulfur in fruits, possibility contributing to the stronger flavor.
3. **Accomplished Summaries:** The significance of these studies is that energy-efficient light not only produces earlier and higher yield, but also reduces water and fertilizer usage, and produces higher quality fruits than conventional HPS lamps.
4. **Impact Statements**
5. **Published Written Works**

Presentations

1. **Kim, H.J.**, M.Y. Lin, C. Gomez, and C. Mitchell. 2017. Supplemental Far-Red Light-Emitting Diodes (LEDs) Increase Yield of Greenhouse Tomato Via Morphological and Physiological Changes. American Society for Horticultural Science, Waikoloa, HI. September 19-22, 2017 (oral presentation).

2. M.Y. Lin, C. Gomez, C. Mitchell. and **H.J. Kim.** 2017. Physiological Responses of High-wire Tomato to Intracanopy Light-emitting Diode Towers vs. Overhead High-pressure Sodium Lamps. American Society for Horticultural Science, Waikoloa, HI. September 19-22, 2017 (poster presentation).

Krishna Nemali Lab Report for 2018

Assistant Professor, Controlled Environment Agriculture
Horticulture & Landscape Architecture, Purdue University

Dr. Nemali is challenged with developing extension, research and teaching programs in a rapidly growing area of controlled environment agriculture, i.e., greenhouse and indoor-based hydroponic production. In addition, he supports floriculture industry through extension, research and teaching in his program. He is focused on developing region-specific best production technologies that improve sustainability by reducing resource wastage, minimizing environmental impact and increase profits using affordable and robust technologies

1. **New Facilities/equipment:**
    a. A hydroponic facility with two production systems (nutrient film technique, NFT an deep flow technique, DFT) and capability to conduct replicated trials for different varieties under four nutrient solution concentrations and three supplemental lighting treatments was built for research, extension and teaching purposes was built at Purdue University Greenhouse Facility
    b. A vertical farm production facility to grow leaf greens and herbs under different sole source lighting treatments and nutrient solution concentrations was built for research, extension and teaching purposes
    c. An ebb-flow production facility for growing floriculture crops was added in the greenhouse for research activities
    d. A plant phenotyping station capable of automatically measuring canopy area and crop reflectance at different wavebands was added to controlled environment research

2. **Unique plant responses/research accomplishments:**
    a. Photosynthetic photon efficiency is commonly used to market sole-source or supplemental lighting fixtures. Research at Purdue using different sole source LED lighting fixtures with different light composition indicated that energy use efficiency (g/KWh) was linearly related to crop light use efficiency (g/mol) and not related to photosynthetic photon efficiency (mol/KWh).
    b. Smartphone based measurement of plant N status is an ongoing project in our lab. Recent results, based on poinsettia and petunia species, indicated that image analysis technique can be used to remotely measure N content of plant stands in floriculture production.
    c. Hydroponic lettuce is commonly grown under NFT and DFT systems. Our research indicates that DFT system can yield higher yields than NFT system and the differences were related to better nutrient uptake by roots from the recycling solution under DFT than NFT.

3. **Impact statements.**
    a. A new course 'controlled environment production of horticulture crops' was taught during spring 2018. First batch of 11 students completed the course with flying colors! Student projects included building hydroponic production systems, studying economics of growing lettuce under sole source lighting and economics of supplying growing lettuce with artificially heated nutrient solution under colder air temperatures.
    b. Two hydroponic workshops were conducted in 2017 at Purdue University. A total 95 growers attended the workshops. Growers learned about Artificial lighting and nutrient requirements of hydroponic crops and were exposed to research being conducted at Purdue.
    c. Dr. Nemali manages controlled environment agriculture website (www.purdue.edu/hla/sites/cea) specifically developed for growers, extension educators, students to visit extension and applied research pages. The extension page hosts Purdue Greenhouse Newsletters, Extension Bulletins and Greenhouse Archives. In November, December 2017 and January 2018, Dr. Nemali's website had total unique site visits of 3172, 2625 and 2909, respectively averaging 2902 unique views per month (source: Angelfish).

4. **Published works**
    a. A new series, controlled environment production of horticulture crops is now available at Purdue education store. The articles can be downloaded free of cost
    b. A short communication series for controlled environment production entitled 'Purdue Greenhouse Newsletter' is also available online for growers

C.A. Mitchell Lab Report for 2018

Two projects were conducted in the CAMLab during the 2017-2018 reporting year, one relating to the NASA-sponsored ILSRA project to do ground-based work in support of growing vegetables on the International Space Station in preparation for a routine pick-and-eat scenario.

1. **New Facilities and Equipment.** For the Minitron III controlled-environment/gas-exchange system, modified design and assembly progressed towards completion and routine operation. Several improvements were made for ease of operation, for safety compliance, documentation of components, operation, and trouble shooting. Components of the gas-routing board were changed out to not bind CO_2 or H_2Ov over time of operation, and a booster pump and digital rotameter were installed to ensure return of stirred sample atmospheres from the cuvette space to the IRGA following the large pressure drop.
2. **Unique Plant responses.** *Brassica rapa* cv. Tokyo Bekana (Chinese Cabbage) grown in analogue ground-based growth hardware for the international Space Station (ISS) performed poorly under environments designed to mimic those existing on ISS. Plants

grown in a greenhouse or in growth chambers in the lab grew productively under typical ground-based growth environments. Even though Chinese cabbage was the number 1 candidate crop species for growth on ISS in preliminary screening tests on the ground at the Kennedy Space Center, it performed poorly in growth chambers under ISS-like conditions (except for micro-gravity).

3. **Accomplishment Summaries.** For the **NASA ILSRA** project, controlled environments proved to be at least part of the reason why Chinese cabbage failed to thrive under ground-based conditions mimicking the ISS cabin environment in which edibles are grown in veggie plant-growth units. Controlled-environment plant-growth rooms on the ground mimicked ISS humidity, temperature, and CO_2 concentrations. In addition, the use of ground-based Veggie-analogue growth chambers, called Biomass Production Systems for Education (BPSes), allowed us to re-create the light and controlled-release fertilizer environments that also are used in space, many by default rather than by choice. From the outset, it became obvious that Chinese cabbage was not happy with one or more conditions under which it was being grown. This triggered a systematic investigation of environmental and/or cultural conditions responsible for the impaired growth, chlorosis, and necrosis that were observed for every experiment. Investigations included whether the Veggie "pillows" the plants were growing in (to prevent media and water from floating away in the ISS cabin were causing rootzone hypoxia; whether the arcillite plant-growth medium being used was causing micro-nutrient toxicities; whether focused red light from the BPSe was causing photobleaching of leaves leading to chlorosis, necrosis, etc.; and whether the balance of different controlled-release fertilizers was causing nutrient deficiencies. Attempts included different red:blue ratios of light, pre-leaching of arcillite medium, switching from pillows to a larger cylindrical growth system likely to deliver more O_2 to the root system, growth in the greenhouse under natural solar light, and more. Other than plants grown in the greenhouse looking normal, all efforts to find limiting factors were ineffective, until supra-optimal CO_2 was investigated. The CO_2 environment of ISS averages 2800 umol/mol, about 7-fold higher than ambient on Earth. Systematic investigation of Chinese cabbage growth in response to different CO_2 concentrations found that growth impairment and likely CO_2 narcosis leading to chlorosis and necrosis of leaf tissues began at CO_2 concentrations much lower than 2800 umol/mol. It is possible that other lines of investigation that led to seemingly blind alleys interacted with supra-optimal CO_2, but most growth limitations seemed to be alleviated by correcting the CO_2 environment *per se*.

4. **Impact Statement.** When screening species for growth on the ISS, it is important to mimic all environmental and cultural parameters occurring in space that it is possible to mimic during initial screening on the ground. Because other species that have been grown on ISS, such as 'Outredgeous' leaf lettuce, grow very well under ambient IIs cabin conditions, Chinese cabbage 'Tokyo Bekana' appears to be a genotype that does not react well to those conditions. Whether the negative growth reaction is unique to that cultivar of Chinese cabbage has not been investigated.

5. **Published Written Works.**

Dzakovich, M., C. Gomez, M. Ferruzzi, and C. Mitchell. 2017. Chemical and sensory properties of greenhouse tomatoes remain unchanged in response to red, blue, and far red supplemental light from light-emitting diodes. HortScience 52(12): 1734-1741.

Both, A.-J., B. Bugbee, C. Kubota, R. Lopez, E. Runkle, and C. Wallace. 2107. Proposed product label for electric lamps used in the plant sciences. HoertTechnology 27(4): 544-549.