Purdue University

NCERA-101 2008 Station Report
2007-2008 Activity Report

Rob Eddy, Roberto Lopez, Gioia Massa, and Cary Mitchell

1. New Facilities and Equipment.

Rob Eddy (Plant-Growth-Facilities Manager)
Greenhouse improvements. We have completed all projects associated with our tenth anniversary of moving into the facility (March '98) to reach our goal of having it "better than the day it opened". As noted in station reports of the last three years, we have completed several projects: replacing evaporative pads with ones improved with an exterior coating; replacing motorized shade-curtain fabric with improved material; plumbing acid injection equipment to our clear water supply to neutralize alkalinity.

Last fall we installed new Priva Maximizer logic "motherboards" in all 25 greenhouse rooms of our facility, allowing us to upgrade several generations to the most recent software, Priva version 10. The hardware upgrade allows for up to 40 outputs (fans, curtains, lights, irrigation, etc.) and 30 inputs (sensors) in each greenhouse. The software includes new capabilities in energy savings and irrigation programming, as well as enhanced usability and graphing. Communication speed along the network of greenhouse zones also has been increased. Other hardware purchased in the Priva upgrade package included 4 Li-Cor quantum sensors that will allow us to track daily light integrals inside the greenhouse. We have mounted those sensors on stands for portability. Also included is Priva's "Plant Temperature Camera", a Heitronics Infrared Radiation Pyrometer with range of -10°C to 50°C. We are currently installing this camera with hopes of comparing operation of a greenhouse using plant temperature against one using air temperature.

This winter we replaced the high-intensity discharge fixtures in our two 900 square-foot growth rooms with PARsource 1000W digital electronic ballasts. Each room has 28 fixtures with an average light intensity of 400 $umol \cdot m^{-2}s^{-1}$. The cooler-operating electronic ballasts allowed us to place them directly in the room, rather than remote-ballasting. The previous configuration had led to premature failure of the fixtures over the years due to the distance of the remote ballasts. No modification of the HVAC system was required, though the ballasts are now inside the growth room. The lamps are evenly split between metal halide and high pressure sodium vapor; the electronic ballasts allow for either lamp type in any fixture so this ratio could be changed as needed.

Over 40 HID fixtures were hung in the greenhouses in 2007, donated from the Indiana State Police from drug busts. Four Percival chambers were purchased by researchers and folded into our Plant Growth Chamber Center of 60 chambers in three locations on the College of Agriculture campus.

Roberto Lopez (Floriculture Research)

High Pressure Sodium Lighting Installation. Sixteen energy-efficient PARSource 1000 Watt HID lamps with remote digital electronic ballasts were installed in each of three greenhouse compartments dedicated to floriculture research. We have the capability of turning half the lamps on to create conditions similar to a commercial greenhouse with supplemental lighting or use all 16 lamps for high daily light integral (DLI) experiments without compromising uniformity. For example, when 8 or 16 lamps are on from 0600 to 2200 HR, we can provide supplemental lighting of ≈90 or 200 $\mu mol \cdot m^{-2} \cdot s^{-1}$, respectively, at canopy level for a daily light integral (DLI) ≈5.2 or 11.5 $mol \cdot m^{-2} \cdot d^{-1}$, respectively. In addition, we have installed Spectrum technologies WatchDog 2000 series data loggers capable of measuring DLI, temperature, leaf wetness, and soil moisture.

Gioia Massa and Cary Mitchell (Optimizing Food & Biomas Production)

LED Lighting. Much of the past year was occupied testing the HELIAC 2 adaptive control LED lighting system developed by ORBITEC as part of a Phase 2 NASA SBIR. Initial tests were performed with lightsicle arrays in the intracanopy configuration for three ALS candidate crops: cowpea, tomato, and sweetpotato. A variety of green-light-flash detection patterns with parameters such as threshold of photodiode detection and light-flash intensity were tested at different ages for those crops. Plants were started in the greenhouse and transferred to the HELIAC system for detection runs. These tests allowed us to develop baseline detection parameters that subsequently were used in a long-term study of cowpea grown hydroponically. That test allowed us to determine how the detection system worked with continually changing plant biomass. One observation was that internal reflectance from the highly-reflective white walls caused false detection. This led to a followup cowpea test with the HELIAC growth compartment split into two sub-compartments, each containing 8 lightsicles. One sub-compartment was lined in matte-black felt while the other retained the white reflective walls, and detection parameters were periodically adjusted to find optimum settings. A third HELAIC 2 test was conducted with the lighting system in the overhead configuration and using lettuce as the test crop. These testing situations allowed both hardware and software troubleshooting, and the system has been returned to ORBITEC for modification.

Testing of the incidence of intumescence was performed using tomato as the test species. Fluorescent blacklights (360 nm) were used in effort to mitigate intumescence in other solanaceous species grown with red and blue LED lights. ‘Persimmon’ tomato plants failed to develop intumescence, indicating that intumescence formation is a species-specific response to LED lighting.

2. **Unique Plant Responses**.

Rob Eddy

Rice (‘Nipponbare’) growing methods development. As we did with *Arabidopsis* in 2006, we hoped to develop a rice-growing protocol that would not only benefit our researchers, but would be repeatable at other facilities. Our study indicated lower germination and slow growth with sandy-loam mineral soil. A commercial soilless mix resulted in micronutrient deficiency, in some cases causing plant death. Best growth was achieved using a medium of calcined clay granules (Profile Greens™) fertilized twice weekly with 15-5-15 fertilizer at 200 ppm N. Amendment of mineral soil with these granules in a 1:1 ratio by volume also resulted in good growth. These two media required no supplemental iron applications for the plants to maintain green color. As a follow up, we are currently comparing pot size and fertilization frequency using the calcined clay granules.

Sylvania Primary Color Fluorescents (PCF) testing. We validated that plants grow normally under a 2:1 mixture of red and blue PCF lamps, respectively, developed by Sylvania for architectural effects. These are T5 HO (54 watt) lamps that come in red, blue, and green. We observed no difference in growth or flowering of *Arabidopsis*, corn, zinnia or tomato using these lamps as compared to cool-white fluorescent at equal lighting intensity.

Powdery Mildew study using environmental controls. In a study this summer, we were unable to reduce the spread of powdery mildew on *Cleome* (Spider Flower) by modifying the greenhouse environmental programming. Using four greenhouse rooms, we modified ramp times between night and day temperatures and also developed a pulsed dehumidification program. Disease on the potted *Cleome* spread to severe levels in all treatments.

Roberto Lopez

Low Input and Cool Temperature Poinsettia Production. As energy costs continue to increase, greenhouse growers are seeking poinsettia cultivars that can be grown at cooler average daily temperatures. We screened 27 poinsettia cultivars to determine which could be successfully produced for a market time frame at average daily temperatures of 22 or16 °C. Plants were grown in the Purdue Plant-Growth Facility Greenhouses with temperatures set points of 24 °C day/19.5 °C night until the beginning of short days. At that point half the plants were moved to 18.5 °C day/ 14 °C night. The short-day photoperiod consisted of an 8-h natural day achieved using blackout cloth from 0800 to 1600 HR. Data are currently being entered and analyzed.

Gioia Massa and Cary Mitchell

Strawberry. A 234-day strawberry-production experiment was conducted using three reach-in growth chambers. Ten day-neutral ‘Seascape’ strawberry plants were exposed to 400 $\mu mol \cdot m^{-2} \cdot s^{-1}$ incandescent and fluorescent light under each of three different photoperiods: 10, 12, or 14 hours. Previous tests indicated equivalent yield at other tested photoperiods (equivalent to what?), so the object of this testing was to determine the minimum amount of light energy that could be used to produce fruit without a decrease in yield or fruit quality. Plants were pollinated using a vibrating wand three times weekly and fruit were harvested weekly. Taste testing was performed on fruit, and they were rated for qualities such as sweetness, tartness, texture, etc. Statistical analyses of data suggest a strong dependence on plant age for yield as well as many fruit-quality parameters, but very little influence of photoperiod influence, indicating that ‘Seascape’ might be an ideal strawberry cultivar for controlled-environment production.

Sweetpotato. Two 120-day sweetpotato experiments were conducted with vines trained to climb around wire frames. The first study looked at incorporated time-release fertilizer versus fertigation. Plants with the time-release fertilizer showed nutrient deficiencies, probably due to leaching of the fertilizer. This experiment is being repeated with shorter durations of watering (no-runthrough the container) and supplemental application of nitrogen and potassium to levels favorable for sweetpotato production. A second study compared vine growth and storage-root development in three different growth media, a high-porosity, peat-based medium and two calcined-clay media with either large (>2mm) or small (<1mm) particle sizes. Those plants were all fertigated to run-through, and both shoots and roots were weighed at harvest. Data from that experiment indicated that the large calcine clay particulate matrix produced poor shoot and root growth, while the peat-based and small-particle-size media had high yields. The shoot : root ratio was the same for all treatments. The experiment in progress is integrating those two experiments, with a larger replicate comparison of the two media types as well as a comparison of fertigation versus integrated fertilizer in both media.

Corn. Corn was grown to harvest maturity in a growth chamber under temperature DIP conditions using two different pot sizes. That study will be continuedwithout DIP temperatures for comparison following chamber repairs. Even though plants grown in larger pots produce tillers and tiller ears, there was no difference in the weight of seeds produced per pot under DIP conditions. In a growth-room study on light quality, a second replicate was conducted comparing corn growth under HPS alone, MH alone, 60% HPS:40% MH, or 50% HPS: 50% MH, all at the same PPF at canopy level. Once again, plants grown under a single lamp type had greater seed number and total seed weight than those grown under mixed lamps, due at least partly to a greater percentage of plants setting seed under the single lamp types.

Greenhouse studies with corn have focused on using Sumagic as growth regulator that ffectively reduces plant height while stimulating tillering and seed production. A dose-response trial with Sumagic was conducted on 72 corn plants with 8 different doses and a control, but hot summer temperatures at an early stage of growth reduced pollen shed drastically, and poor seed set resulted for all treatments and the controls. A subsequenttest examined seed production with and without tillers (manual removal) resulting from application of effective Sumagic concentrations, but again the seed yield was reduced due to heat stress. These experiments are being repeated earlier in the year and indicate the need for adequate temperature control for yield studies with maize .

High-Tunnel Project. Purdue University is installing a closed-loop underground water-recirculation system that will conduct hot wastewater from the campus power plant below a site where high tunnels will be erected during the summer of 2008. Worst-case calculations indicate that bottom heating root systems will keep temperatures above chill range for crops growing in high tunnels and will greatly extend cropping seasons, possibly to a year-round basis. A variety of specialty crop and biofuel feedstock test species will be established within the tunnels during the summer of 2008 and tested for productivity and yield during the 2008-2009 cold season. The project will test proof of concept for off-season crop production in temperate climates, thereby avoiding negative impacts of fossil-fuel use related to long-distance transportation and crop production.

3. **Accomplishment Summaries**.

LEDs. Crop quantum efficiency has been incrementally improved by distributing relatively cool photon emitters into foliar canopies of planophile crops, more closely matching absorption spectra of plant pigments with emission spectra of emitters, adjusting plant position within stands relative to emitters, and optimizing reflectance properties of growth-compartment surfaces to retain emitted photons within crop stands until they are absorbed by leaves. **Strawberry.** A combination of cultivar selection and diurnal temperature and photoperiod optimization led to long-term production of good-quality strawberries with reasonable yield. **Sweetpotato.** The growth area and volume occupied by shoots in producing a reasonable yield of storage roots was minimized by pinching, training, nutritional management, and choice of growth medium. **Corn.** Growth temperature, container volume, and light quality were manipulated to promote synchronicity of pollen shed and silk receptivity, tillering, and reasonable yield of maize in a controlled environment. Plant-growth retardants were found to reduce stem length, promote tillering and secondary ear formation, and overall seed yield of corn grown in greenhouses. **High Tunnels.** Engineering calculations indicate that it is feasible to bottom heat high tunnels and permit out-of-season production of specialty crops during winter in temperate climates.

4. **Impact Statements**.

Projects on intracanopy LED lighting systems, strawberry, and sweetpotato all have decreased the Equivalent system Mass (ESM) required for growing crops in controlled environments for future space life-support systems. Reductions in total energy use for lighting, for growth space and volume occupied, and for extended production of anti-oxidant-containing foods have decreased the penalties of sustaining human crews at distant space destinations without resupply of life-support consumables. The project to optimize conditions for growing corn in controlled environments defines environmental requirements for the consistent, productive yield of transgenic corn in isolation and containment for the future pharma-crop industry. The high-tunnel project is providing information needed for new business startups to be successful in growing specialty crops year-round in temperate climates.

5. **Published Written Work**

Lopez, R.G. 2008. OFA Fact Sheet: Cutting propagation. OFA – An Association of Floriculture Professionals Bulletin 906:13−14.

Lopez, R.G. and J. Beckerman. 2008. Avoiding the Easter Lily Production "Blues". Purdue Plant and Pest Diagnostic Lab Picture of the Week, Feb. 11, 2008. http://www.ppdl.purdue.edu/PPDL/weeklypics/2-11-08.html

Lopez, R.G. 2007. The Indiana Flower Grower Newsletter 1(1):1−12.

Lopez, R.G. 2007. 2008 Indiana Easter lily guidelines. The Indiana Flower Grower Newsletter 1(1):2−4.

Lopez, R.G. 2007. Steps toward sustainablity. Greenhouse Grower 25(14):8.

Lopez, R.G. 2007. Chlorotic and bleached stems and leaves in poinsettia. Purdue Plant and Pest Diagnostic Lab Picture of the Week, Oct. 29, 2007.

Russell, J., **C. Mitchell**, J. Pekny, S. Aydogan, M. Lasinski, 2007. Characterizing Crop-Waste Loads for Solid-Waste Processing. Proceedings of the International Conference on Environmental Systems (ICES) 2007 (01): 3187.

6. **Scientific and Outreach Oral Presentations**.

Lopez, R.G. 2008. Increase your success and profitability in growing vegetative annuals. Toledo Flower and Vegetable Growers Association, Sylvania, Ohio, February 28.

Lopez, R.G. and **R. Eddy**. 2008. Greenhouse production of bedding plants and herbs workshop. Indiana Horticulture Congress, January 29.

Cañas, L., C. Bogran, C. Pasian, **Lopez, R.G.** and C. Sadof. 2008. Greenhouse and nursery spanish educational program: Pest identification and management. Syngenta Crop Protection Workshop, Westfield, IN, January 16.

Lopez, R.G. 2008. Increasing greenhouse efficiency. Indiana Green Expo, Indianapolis, IN, January 15.

Lopez, R.G. 2007. Stock plant photosynthetic daily light integral influences instantaneous light response, cutting quality, and yield. International Conference on Quality Management in Supply Chains of Ornamentals: QMSCO 2007, Bangkok, Thailand, December 4.

Lopez, R.G. 2007. Light quantity and effects on plant growth an development. Northwest Indiana Floriculture Association (NWIFA), Crete, IL. November 8.

Lopez, R.G. 2007. Propagation essentials. Indiana Flower Growers Association Annual Meeting, West Lafayette, IN, October 18.

Lopez, R.G. 2007. Using paclobutrazol as a liner dip on vigorous vegetative bedding plants. OFA Short Course – Research Update, Columbus, OH, July 15.

Mitchell, C. and **G. Massa.** 2007. Future Technologies for High Tunnels. Invited presentation, Indiana Horticultural Congress, Indianapolis, January 31.

Mitchell, C.A. 2007. The Essential Role that Plants will play in Closing Loops for Space Regenerative Life-Support Systems. Invited presentation to Plant Biology Graduate Program Seminar Series, Rutgers University, New Brunswick, NJ, February 23.

Mitchell, C.A. 2007. Sustaining human life in space with help from plants and bioprocessing. Invited presentation, Mid-American Collegiate Horticulture Society (MACHS), Purdue University, March 9.

Mitchell, C.A. 2007. Artificial closed-loop ecosystems for extended habitation in space. Invited presentation to the Purdue Students for the Exploration & Development of Space (SEDS), Purdue University, April 12.

Mitchell, C.A. 2007. Utilization of controlled environments for plant research to enable lunar food production. Invited presentation, Session I: Food supply challenges, workshop on Research enabled by the Lunar environment, National Research council, National Academy of Sciences, Washington DC, June 14.

Massa G.D., Kim H.-H., Wheeler R.M. and **C.A. Mitchell.** 2007. Plant studies and responses with LEDs. Invited Presentation, CEWG Workshop on Light-Emitting Diodes (LEDs) in Horticulture, ASHS 2007, Scottsdale, AZ, July 18.

Schluttenhoffer, **G.D. Massa**, and **C.A. Mitchell**.2007. The effect of plant-growth retardants on growth and reproductive development in *Zea mays.* ASHS 2007, Scottsdale, AZ, July 18.

Mitchell, C.A. 2007. Mechanical stress regulation of plant growth and development. Invited seminar in the Department of Environmental Sciences, Greenhouse Production research Group, University of Toledo, OH, August 31.

Mitchell, C.A. 2007. How controlled environments will enable regenerative agricultural systems in the twenty-first century. Invited seminar in the Department of Environmental sciences, University of Toledo, OH, August 31.

Massa G.D., Bourget C.M., Morrow R.C., **Mitchell C.A.** 2007. Testing of the HELIAC 2 plant detection and lighting system. ASGSB 2007, Ames Research Center, CA, October 27.

Mitchell, C.A. 2007. "Going green at home". Invited telecon presentation and Q & A session with a 6th grade class in the New Jersey Public School System (Hawkins St. School), Carmelita Mirza Tech Coordinator, Paulo Sociedad Teacher, November 15.