Purdue Station Report - 2009

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Impact Nugget:

Purdue University has generated online resources for optimum production of controlled environment rice. Controlled environment optimization of several crops is underway using control systems, sensors, and lighting technology.

New Facilities and Equipment:

We have successfully installed several sensor types in our floriculture research greenhouses, interfacing them with the Priva greenhouse control system. Three Li-Cor quantum sensors collect greenhouse light intensity at canopy level. Priva's "Plant Temperature Camera", a Heitronics infrared radiation pyrometer, measures canopy temperature across a greenhouse bench of plants. In one study, we successfully operated climate control of a greenhouse room using leaf canopy temperature rather than air temperature. Six Omega Engineering non-contact infrared temperature sensors, Model OS136-1, measure temperatures of individual plants in 4 separate rooms. An offset value had to be used in calibration of the probes to have them measure in the correct range when interfacing with Priva. Two Decagon ECH20 Soil Moisture Sensors, model EC-5 log soil moisture.

An Aqua Systems water polishing system was installed to remove metals from the R/O water feeding into the mist humidification system in our custom tall EGC growth chamber. This was in response to long-term issues with spray nozzle clogging. Ion coupled plasma mass spectroscopy (ICP-MS) was performed on water coming out of the reverse osmosis system, as well as the clogging residue, and metals including Cr, Fe, K, Na and Zn were found in the water and residue. Additionally Cu, Ni and Pb were found concentrated in the residue/corrosion on fittings in the water reservoirs, but not in high levels in the water. Our humidification issues appear to be solved by addition of the water polishing system, along with changing out lines, reservoirs and nozzles.

We have received delivery of all of the components for our custom gas-exchange cuvette system for use with intracanopy LED lighting. Graduate students in mechanical engineering technology and electrical engineering technology are assembling and integrating structural components and sensors and control systems which include a USB video camera for internal monitoring, Vaisala temperature and humidity probes, differential and absolute IRGAs and mass flow controllers allowing rapid equilibration to setpoints.

The waste-energy leveraged high tunnel project at the Purdue power plant has been sent out for design review. Project bidding will occur this spring and site construction should be finished by August ready for an initial fall planting.

Unique Plant Responses:

Rice ('Nipponbare') growing methods development. We completed our two-part study using Oryza sativa japonica 'Nipponbare' to achieve these goals: Optimize growth

and yield without requirement for using field soil; No supplemental or corrective fertilizer applications; Limited mixing of soil components; Repeatable, reportable methodology using readily available materials; Scaleable production system for large research projects. In the first study, we concluded the best root medium was calcined clay granules (Profile Greens™) fertilized twice per week with 15-5-15 fertilizer at 200 ppm N. The second study confirmed the fertilization frequency as optimum and 4-inch pots as the recommended pot size.

Corn growth-regulation. We completed dose response of BT corn grown in a greenhouse with eight concentrations of Sumagic™ and controls. While all concentrations reduced the height and led to tillering, intermediate concentrations had no negative impact on seed yield and some concentrations even enhanced yield. Sumagic™ treatment, therefore, can be used, to effectively reduce the height of CE-grown corn without reducing yield, and this has implications for future CE-production of pharmaceutically transformed corn.

Strawberry temperature analyses. Day-neutral strawberry plants ('Seascape') were grown long-term under 10-hr photoperiods in three reach-in chambers set to day/night temperatures of 16˚/8˚, 18˚/10˚, 20˚/12˚. Although all plants produced fruit, the temperature settings offset production so that fruiting of the coolest plants was delayed several months with respect to the warmest plants. This provided difficulties with organoleptic analysis comparisons. Currently, this experiment is being repeated, but rather than depending on organoleptic analysis for fruit quality, BRIX and pH, and titratable acidity analyses will be performed.

Sweetpotato plant nutrition/media testing. Trials of different media types indicate that root yield was more consistent in small-particle calcined clay (Profile Greens™) compared to a peat-based high porosity media. Pressure regulated emitters were used to deliver precise quantities of water and fertilizer to roots of plants grown in calcined clay granules (Profile Greens™). The goal of this research is to increase the root/shoot ratio by applying reduced fertilizer concentrations. Preliminary analysis indicates that intermediate concentrations may give a better root:shoot ratio to higher fertilizer concentrations without impacting storage root yield. This experiment is being repeated with greater numbers of plants.

Tomato cultivar analysis. Twelve cherry and grape tomatoes were grown in the greenhouse under three different management practices (caged, staked, free-range). Plants were assessed for growth habit, height and volume of space occupied and fruit production. Two cherry cultivars, 'Small fry', the 3rd highest yielding with relatively compact growth in the greenhouse, and 'Husky cherry red', the most compact cultivar with decent fruit production, were chosen for further testing with intracanopy and overhead LED light arrays in a walk-in growth chamber. Production is ongoing, however both cultivars are flowering and setting fruit under LED-lit conditions. 'Small fry' is exhibiting severe intumescence in response to 640 and 440 nm light (20% blue, 400 µmol/m^2/s) and also was very sensitive to a heat stress episode, while 'Husky cherry red' appears to have normal growth under the same conditions.

Poinsettia cold finishing. The potted holiday poinsettia is a high-input, lower-value floriculture crop that is produced in greenhouses throughout the United States from July to December. The economic sustainability of poinsettia growers is increasingly threatened as the cost of fuel (e.g., natural gas and heating oil) for heating has more than doubled in the past ten years. In a collaborative effort between the University of New Hampshire and Purdue University ten poinsettia cultivars were moved on 15 October to day/ night temperatures (12 h/12 h) of 61/ 55 °F (ADT 58 °F), 68/ 56 °F (ADT 62 °F), constant 62 °F (ADT 62 °F), 70/ 62 °F (ADT 66 °F), constant 66 °F and 75/ 67 °F (ADT 71 °F). Air, medium and plant temperature, light intensity, energy consumption and water usage were recorded in all growing environments using enclosed aspirated thermocouples, quantum sensors, and Priva or Argus controllers connected to dataloggers. Temperatures, daily light integral, days to first color, days to marketability and anthesis (pollen shed), bract expansion, inflorescence area and weekly plant height (graphical tracking) until anthesis were collected.

Accomplishment Summaries:

Using rice ('Nipponbare'), greenhouse studies were performed to optimize growing methods. This research identified the best root medium as calcined clay granules (Profile Greens™), with a fertilizer regimen of 15-5-15 fertilizer at 200 ppm N, twice per week. Four-inch pots are the recommended pot size.

Experiments using different dosages of Sumagic™ on Bt corn demonstrated that 0.5 to 1 ppm of this growth regulator could reduce height without having a negative impact on plant yield.

Much of the research at Purdue University has focused on increasing the use of sensors and control systems in greenhouse horticultural production. The focus of this research is to reduce the energy needed for successful crop production by increasing the efficiency of automation and supplemental lighting, only lighting when necessary, and reducing the temperatures needed for certain stages of crop growth.

Impact Statements:

The research at Purdue University is designed to optimize crop growth to allow for more efficient use of energy and resources. Work with strawberry and poinsettia has focused on optimizing temperature to reduce the energy needed in production. By determining what conditions are tolerated at different stages of growth, poinsettia crops might be finished under cooler day and/or night temperatures, leading to reduced energy for heating and increased profitability of this high-input, low-value crop. Examining strawberry production and flavor under a variety of temperature combinations might allow earlier or off-season production of strawberries with equal or enhanced flavor.

Other important resources in controlled environment crop production include the inputs of media, water and fertilizer. Research on rice and sweetpotato has focused on determining the impact of fertilizer, container size and growing medium to obtain the maximum edible biomass yield. In both of these crops, as well as in our height-reduced

corn, reducing the space occupied without negatively impacting yield is desirable. Outreach products such as the *Purdue Methods: Rice* website allow this information to be accessed by horticulture producers, researchers, and the general public.

Labor costs in crop production are another key input. Increasing automation through the use of sensors and control systems can minimize the labor needed to produce a crop, and work at Purdue focuses on automating the growth environment in response to an enhanced array of sensors measuring factors such as canopy temperature. Characterization of the ability of sensors to increase the efficiency of environmental control will give producers and researchers new options. Crop management practices can also lead to increased efficiency. Work with grape and cherry tomato cultivars will lead to management strategies for these crops under a variety of growth scenarios including novel LED lighting environments. The development of an LED-lit gas exchange system will allow rapid, efficient photosynthetic optimization of light quantity and quality, temperature and CO_2 level for a variety of crops compared to slower, more labor-intensive methods.

Published Written Works:

Massa, G.D., H-H. Kim, R.M. Wheeler and C.A. Mitchell. 2008. Plant productivity in response to LED lighting. HortScience. 43(7): 1951-1956.

Lopez, R.G. 2008. Cold and sustainable poinsettia production. Greenhouse Grower. 26(8):116−123.

Websites developed: *Purdue Methods: Rice.* http://www.hort.purdue.edu/hort/facilities/greenhouse/RiceMethod.shtml
A summary of rice optimization studies, including methods, data, photos, discussion, links and references. Designed as companion site to “101 Ways to Grow Arabidopsis” webpage.

Twenty-five e-publications through Purdue e-Pubs in printable document format based on *Arabidopsis* and rice methodology research described in our websites. The documents are discoverable via Google and OAISTER database.

Scientific and Outreach Oral Presentations:

Lopez, R.G. 2008. Cold and sustainable poinsettia finishing. Indiana Flower Growers Association Annual Meeting, West Lafayette, IN.

Lopez, R.G. and R. Eddy. 2008. Greenhouse Production of Bedding Plants and Herbs Workshop. Indiana Horticulture Congress, Indianapolis, IN.

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

Lopez, R.G. and J. Beckerman. 2008. English and Spanish Workshop - Environmental

management, plant growth regulators and diagnosing problems. Heartland Growers, Westfield, IN.

Martin, C. and R.G. Lopez. 2008. Greenhouse production energy savings opportunities. Indiana Flower Growers Association Annual Meeting, West Lafayette, IN.

Massa, G.D., C.M. Bourget, R.C. Morrow and C.A. Mitchell. 2008. Innovations in LED lighting for reduced-ESM crop production in space. NLSI Lunar Sciences Conference, Ames Research Center, CA.

Massa, G.D., C.M. Bourget, R.C. Morrow and C.A. Mitchell. 2008. Innovations in LED lighting for reduced-ESM crop production in space. 37th COSPAR Scientific Assembly, Montreal, QC, Canada.

Massa, G.D., C.M. Bourget, R.C. Morrow and C.A. Mitchell. 2008. Changing the way light is delivered to plants in controlled environments. 2008 International Meeting on Controlled Environment Agriculture, Cocoa Beach, FL.

Eddy, R. 2008. Optimizing Greenhouse Rice, Corn and Arabidopsis Production. Association of Education and Research Greenhouse Curators annual conference, July 29, Texas Tech University, Lubbock TX.

Other Relevant Accomplishments and Activities:
Gioia Massa and Cary Mitchell were filmed for a History channel program “The Universe: Living in Space” in June, 2008. Program aired December, 2008.

Gioia Massa spoke to students in the Purdue University Gifted Students Summer Program on “Plants in Space.” July 8, 2008.