NCERA-101 Station Report from Georgia, 2015

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1. New Facilities and Equipment

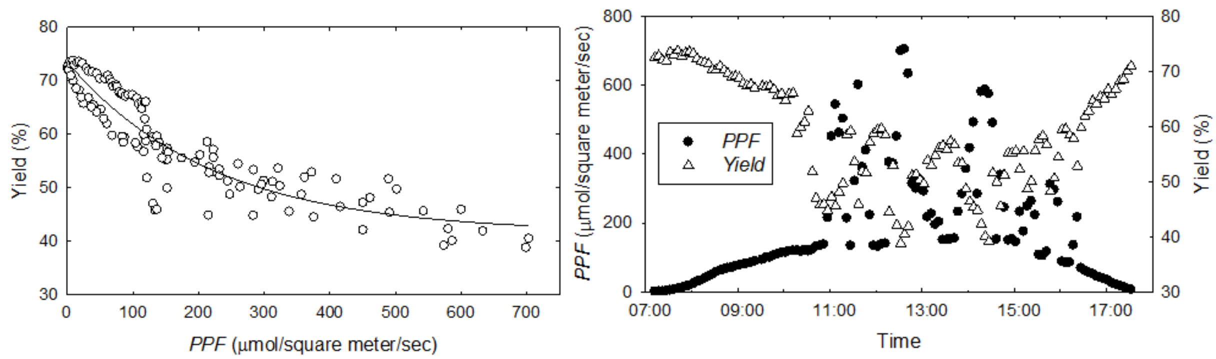
Biofeedback control of LED lights. We have designed and built a custom LED light that can be controlled using a biofeedback system. A chlorophyll fluorometer (mini-PAM, Walz, Germany) is connected to and controlled by a datalogger (CR1000, Campbell Scientific). The datalogger uses chlorophyll fluorescence measurements from the fluorometer to determine the effective quantum yield of photosystem II and calculates the electron transport rate through photosystem II. The measured electron transport rate is then compared to user-defined target rate of electron transport rate. Based on the difference between the measured and target electron transport rates, the datalogger determines whether the duty cycle of the LED light should be decreased or increased. The datalogger than sends a signal to the LED controller to make the necessary adjustment in duty cycle(and photosynthetic photon flux). Two of these setups have been installed inside growth chambers (E15, Conviron).

Automation of irrigation and fertigation. We have designed and built a 16-plot irrigation/fertigation system, which can automatically irrigate or fertigate up to 16 plots, based on substrate water content and electrical conductivity (EC), which are measured using GS-3 sensors (Decagon Devices) connected to a datalogger (CR1000, Campbell Scientific). Whenever the substrate water content drops below a target value for that specific plot, the datalogger compares the measured EC to a target EC. If both the substrate water content and EC are below their respective thresholds, the plot is irrigated using the fertilizer solution. If the measured ECX is above the target EC, the plot gets irrigated using tap water. We have installed NDVI sensors (SRS sensor, Decagon Devices) above each plot to continuously monitor the Normalized Difference Vegetation Index, a measure of canopy size. This allows us to monitor crop growth continuously and non-destructively.

2. Unique Plant Responses

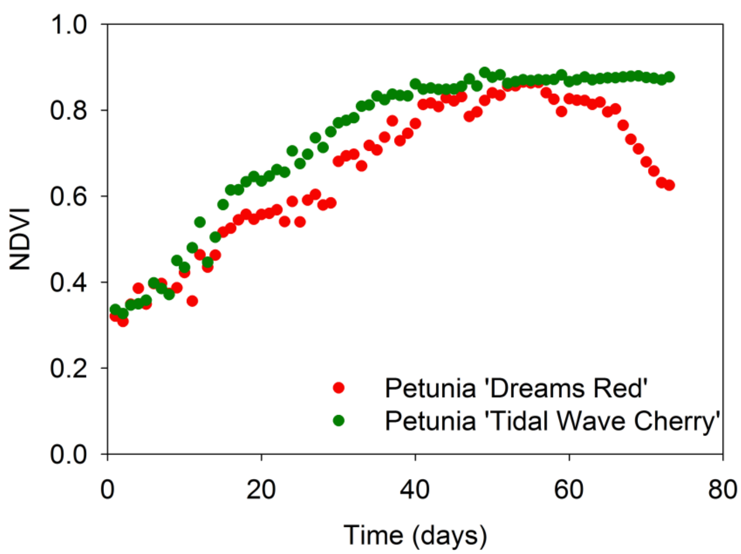
Quantum yield of photosystem II and implications for supplemental lighting
Plants are exposed to rapidly changing light levels over the course of a day. This has important consequences for how efficiently plants use the light that is absorbed by the leaves. The light use efficiency of leaves changes constantly in response to changing light levels and typically is well below the theoretical maximum of 80 to 84%. This efficiency (or yield) can be monitored by measuring how much fluorescence is given off by the leaves. We used a chlorophyll fluorometer to measure the photosynthetic yield of a geranium leaf over the course of a partly sunny winter day in Georgia. The photosynthetic photon flux ranged from 0 to 700 µmol/m^2/s and the yield responded to these changes in *PPF*: the yield was close to 70% at low *PPF* levels, but decreased to about 40% at the highest *PPF* levels. These

changes in yield in response to changing *PPF* have important consequences for supplemental lighting: providing supplemental light when the yield is low will do little to stimulate the light reactions of photosynthesis.



NDVI measurements as an indicator of canopy size

Non-destructive real-time measurements of plant growth can be a valuable tool in many research and production situations. Normalized Difference Vegetation Index (NDVI) measurements are one potential option to collect such data. To test new, relatively low-cost NDVI sensors (SRS, Decagon Devices), we measured NDVI of two petunia cultivars over a 70 d period in winter. The sensors provided good data during the initial vegetative growth phase, but lost sensitivity once the canopy was large. This is a typical response for NDVI and other vegetation indices may be more appropriate for measuring large canopies. Petunia ‘Dreams Red’ flowered prolifically near the end of the study. This resulted in a decrease in NDVI, because the red flowers covered much of the foliage. ‘Tidal Wave Cherry’ produced few flowers and no decrease in NDVI was seen for this cultivar.



3. Accomplishment Summaries

We have developed a functional biofeedback system for control of LED lights. To the best of our knowledge, this is the first lighting control system that controls LED lights based on the efficiency or electron transport rate of photosystem II. The system has been tested with multiple crops and has shown to be able to control the electron transport rate through photosystem II accurately. We expect that implementation of this technology into controlled environment agriculture facilities will give growers better control over crop growth and will reduce electricity costs, since lights can be dimmed automatically when the crop is not using the light efficiently.

Much of our past work has focused on precision control of irrigation in greenhouses and nurseries. We now have expanded this research to also include automation of fertilizer applications. We use electrical conductivity (EC) as an indicator of fertilizer levels in the root zone and use semi-continuous measurements of substrate water content and EC to automate irrigation and fertigation. There are two large challenges remaining, related to this work: 1) EC is much more variable than substrate water content and thus harder to control precisely. Whether that is a true practical concern remains to be seen. 2) Although bulk EC measurements of soils or substrates are easy, interpreting the data is much harder. Sensors provide users with bulk EC (the combination of soil particles, air and solution in the soil) data, but from a practical perspective, pore water EC is much more important. Current models to estimate pore water EC from bulk EC and related data do not seem to work well. Better methods for measuring or estimating pore water EC are needed.

4. Impact Statements

Electricity costs for photosynthetic lighting make plant production in enclosed environments very expensive. We have developed a biofeedback system that allows for control of LED lights based on the plants ability to use that light efficiently. We expect that this technology will reduce electricity costs and make controlled environment agriculture more economical.

5. Published Written Works

Refereed journal articles

Ferrarezi, R.S., Marc W. van Iersel and R. Testezlaf. 2014. Subirrigation automated by capacitance sensors for salvia production. *Horticultura Brasileira* 32:314-320. (DOI: http://dx.doi.org/10.1590/S0102-05362014000300013)

Lu, P., R. F., Davis, R. C., Kemerait, M. W. van Iersel, and H. Scherm. 2014. Physiological effects of *Meloidogyne incognita* infection on cotton genotypes with differing levels of resistance in the greenhouse. *Journal of Nematology* 46:352-359.

O'Meara, L., M.R. Chappell, and M.W. van Iersel. 2014. Water use of *Hydrangea macrophylla* and *Gardenia jasminoides* in response to a gradually drying substrate. *HortScience* 49:493-498.

Starry, O., J.D. Lea-Cox, J. Kim, and M.W. van Iersel. 2014. Photosynthesis and water use by two *Sedum* species in green roof substrate. *Environmental and Experimental Botany* 107:105-112. (DOI: 10.1016/j.envexpbot.2014.05.014)

Weaver, G. and M.W. van Iersel. 2014. Anti-transpirational efficacy and longevity of abscisic acid and a synthetic ABA-analog in pansies (*Viola* × *wittrockiana*). *HortScience* 49:779-784.

Zhen, S., S.E. Burnett, M.E. Day, and M.W. van Iersel. 2014. Effects of substrate water content on morphology and physiology of rosemary, Canadian columbine, and cheddar pink. *HortScience* 49:486-492.

Symposium proceedings

Alem, P.O., P.A. Thomas, and M.W. van Iersel. 2014. Irrigation volume and fertilizer concentration effects on leaching and growth of petunia. *Acta Horticulturae* 1034:143-148.

Bayer, A., J. Ruter, and M. van Iersel. 2014. Irrigation volume and fertilizer rate influence growth and leaching fraction from container-grown *Gardenia jasminoides*. *Acta Horticulturae* 1055:417-422.

Bayer, A. K. Whitaker, M. Chappell, J. Ruter, and M. van Iersel. 2014. Effect of irrigation duration and fertilizer rate on plant growth, substrate solution EC, and leaching volume. *Acta Horticulturae* 1034: 477-484.

Kim, J., J.D. Lea-Cox, M. Chappell, and M.W. van Iersel. 2014. Wireless sensors networks for optimization of irrigation, production, and profit in ornamental production. *Acta Horticulturae* 1037:643-649.

van Iersel, M.W. and S.K. Dove. 2014. Temporal dynamics of oxygen concentrations in a peat-perlite substrate. *Acta Horticulturae* 1034:355-361.

Weaver, G.M. and M.W. van Iersel. 2014. Reducing transpiration of pansies (*Viola ×wittrockiana*) with abscisic acid and 8’ acetylene methyl-ester abscisic acid. *Acta Horticulturae* 1034:567-573.