3:00–3:15 pm

Morphological and Photosynthetic Characteristics of Sun and Shade Pecan Leaves

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An experiment was conducted to investigate the morphologic characteristics and photosynthetic response of sun and shade leaves of mature pecan trees. Treatments were established according to leaf type (sun or shade leaves) and cultivar (Pawnee and Stuart). Sun leaves were chosen from those growing on exterior portions of the tree canopy and exposed to full sunlight for most of the day (>1500 $\mu mol \cdot m^{-2} \cdot s^{-1}$ photosynthetic photon flux density, PPFD). Shade leaves were those growing in interior parts of the tree canopy (<100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PPFD). Photosynthetic light response curves and chlorophyll fluorescence analysis were performed on leaves present on branches (about 2 cm in diameter) which were cut from the mid-portion of the canopy and immediately placed in water. Epidermis characteristics, leaf area, and chlorophyll (chl) content were measured from additional leaves present on the same cut branches. Results indicated that stomatal density (stomata$\cdot mm^{-2}$), leaf area, and leaflet area were greater in sun than in shade leaves in both cultivars investigated. Specific leaf area (m^{-2} leaf area$\cdot kg^{-1}$ DM) was greater in shade than sun leaves. Chlorophyll fluorescence, total chlorophyll content, chl a, chl b, and chl a/b were not affected by either leaf type or cultivar. In both cultivars, photosynthetic light response curves showed that area based maximum assimilation rate (A_{max}) in shade leaves was about half of that measured in sun leaves in June-August. In October, however, A_{max} of sun leaves dropped to values similar to those measured in shade leaves. Light compensation point of photosynthesis and dark respiration rate were always lesser in shade leaves than in sun leaves. Overall there were only minor differences between the cultivars. Pecan trees require careful canopy management to avoid overshadowing and maintain productivity. These results could help determine optimal levels of canopy light interception and intensity of pruning or hedging techniques.

Specified Source(s) of Funding: Department, College, State and/or HATCH

3:15–3:30 pm

Variation in Anatomy and Carbon Isotope Discrimination in Leaves of Pecan Populations from Mexico and the United States

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An assessment of leaf anatomical traits of [*Carya illinoinensis* (Wangenh.) C. Koch] Mexican and U.S. pecan populations grown in a single location was conducted to provide an understanding of patterns of ecogeographic variation within the natural range. For the Mexican populations, pecan stomatal density (SD) and stomatal index (SI) were more closely related to precipitation patterns of the origin site along a longitudinal gradient than elevation patterns along the latitudinal gradient. SD and SI in pecan populations increased along the longitudinal gradient towards the east coast of Mexico. Geographical areas with greater precipitation on the east coast of Mexico had greater SD and SI while the drier areas on the west coast had the least values. In the United States, elevation patterns were along a longitudinal gradient. However, SD and SI did not follow a pattern along the latitude or the longitude in the U.S. populations. An unclear pattern for ^{13}C discrimination in Mexican and U.S. populations translated into the absence of differences between populations for water use efficiency (WUE).

Specified Source(s) of Funding: Federal competitive USDA Germplasm Committee: Pecans

Oral Session 14: Nursery and Ornamental Crops 1

Tuesday, 22 July 2:00–3:39 pm Salon 10

Moderator: Richard C. Beeson, Jr., rcbeeson@ufl.edu

ORALS–TUESDAY

2:00–2:15 pm

Wireless Sensor Networks for Real-time Management of Irrigation and Nutrient Applications in the Greenhouse and Nursery Industry

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We have developed, deployed and tested a low-cost multi-hop wireless sensor network that enables the capture and synthesis of real-time substrate and environmental data on a wide-area basis. Concern over the intensive use of groundwater, deterioration of surface waters, and various state and federal nutrient and water management regulations are making us re-examine the efficiency of water and nutrient management strategies in the nursery and greenhouse industry. Plant water requirements vary by day, season, and microclimate, depending on any number of environmental and plant developmental factors; thus precision irrigation scheduling is extremely difficult. By using the plant to integrate these environmental and growth differences over time, and by accurately monitoring the real-time water use of plants with substrate moisture, temperature, and electrical conductivity sensors, irrigation and nutrient applications can be more precisely scheduled. This can reduce water use, leaching of nutrients, and overall runoff from these intensive growing operations. Additionally, other sensors that simultaneously measure air temperature, canopy relative humidity, leaf wetness, and photosynthetically active radiation will allow us to model and better predict plant growth and disease pressure. We can now provide this data at any time to anyone at any place with internet access, since all data is managed through a web-based graphic-user interface. Since the sensor nodes are portable, growers can rapidly deploy them in specific areas of the operation, to maximize the utility and cost of the sensors. Also, as these networks are scaleable, additional nodes can be added, allowing for an operation to grow and/or improve their sensor network at any time. We will compare and contrast the cost and utility of this research sensor network with a commercial wireless sensor network that has been installed on a tree farm in Maryland, to improve water and nutrient management efficiency.

Specified Source(s) of Funding: Department, College, State and/or HATCH Private (Association, Foundation, Industry) Maryland Agricultural Experiment Station / Maryland Cooperative Extension / Chesapeake Bay Trust / Horticultural Research Institute

Wireless Sensor Networks for the Nursery and Greenhouse Industry

For Real-time Management of Irrigation and Nutrient Applications

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George Kantor, Joshua Anhalt

The Robotics Institute
Carnegie Mellon University

⇨ Need to conserve irrigation water and reduce nutrient applications

- What progress have we made with a sensor-driven approach to irrigation management?
- What are the main issues and challenges with implementation?
- Can we do this cost-effectively?

Primary Objective:

To create an infrastructure to collect and report real-time data from a number of sensors, over large areas

Concept:

Deploy self-contained, wireless sensor nodes that form networks and relay data back to a central 'processing' location

Desired features:

- ✓ low cost
- ✓ scaleable – i.e. we can grow networks over time
- ✓ reliable
- ✓ easily deployed
- ✓ low power and low maintenance
- ✓ data management software is intuitive; graphical presentation

Current Focus

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- Deployed Three Networks
  - Working through implementation issues with growers
  - Placement, variability, interpretation issues
  - Integration with irrigation control systems
- Performance
  - Calibration of sensors; soilless substrate characterization
  - Sensor placement in the root zone; real-time monitoring of readily-available H_20 and EC
  - Monitoring and control of irrigation events w/ both data streams

1. Decagon Devices, Inc. Network

- Fully integrates all $Ech_2 0$ sensors plus a number of other sensors
- Node runs off 4 ‘AA’ batteries – life dependent on # sensors and frequency of sensing
- At least 6-month battery life
- Plug ‘n play operation
- Line of sight transmission
- No control capability
- Only five sensors per node

Production System Variability – Soil Systems

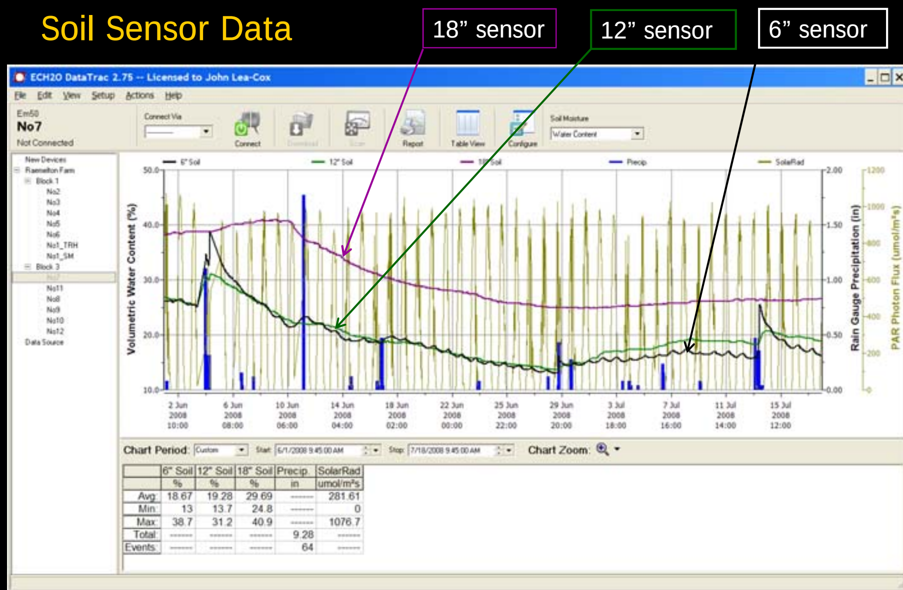
➔ More Extensive Root Systems

- Custom $Ech_2 0$-5cm sensor calibration for both blocks
- Sensor placement issues very important

➔ Tree Water Status

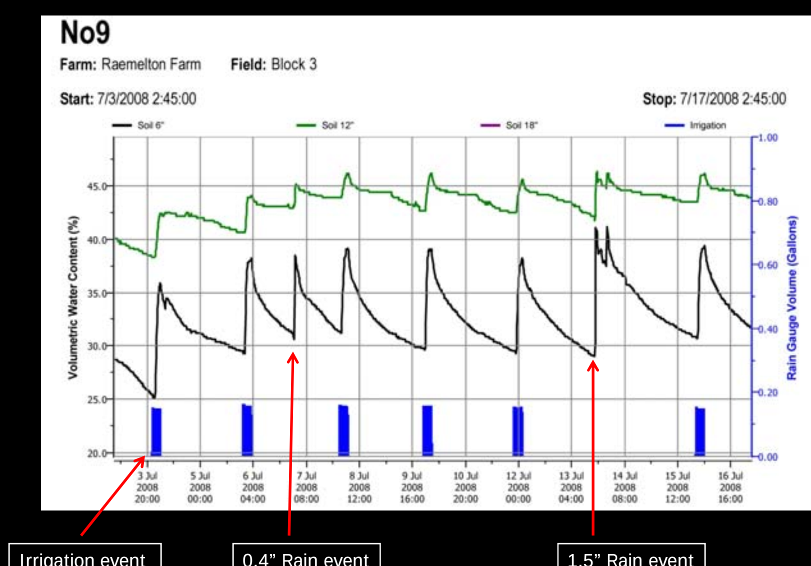
- Control / promote growth
- Reduction in pruning frequency
- Improve nutrient uptake efficiency

Soil Sensor Data



	6" Soil	12" Soil	18" Soil	Precip.	SolarRad
	%	%	%	in	umol/m²s
Avg:	18.67	19.28	29.69	------	281.61
Min:	13	13.7	24.8	------	0
Max:	38.7	31.2	40.9	------	1076.7
Total:	------	------	------	9.28	------
Events:	------	------	------	64	------

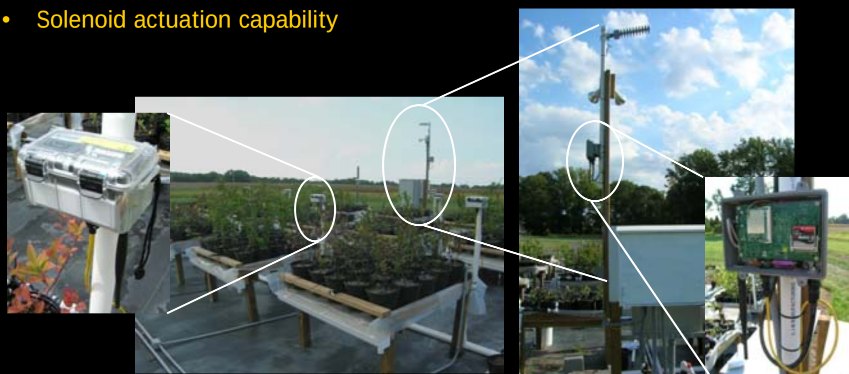
Soil Production Environments



2. CMU Network

Carnegie Mellon THE ROBOTICS INSTITUTE

- One year battery life (4 ‘D’ cells)
- Integrates a full range of Ech$_2$0 and environmental sensors
- Analog – 5 sensors / node capacity; Digital – 10 sensors /node capacity
- Multi-hop network (geographical forward routing capacity)
- Solenoid actuation capability



Soilless Substrate Production Environments

➔ Many sources of variability, due to the built environment

➔ Sensor placement should aim to reduce this variability as much as possible

➔ The premise is that plant growth integrates water use, over time

➔ Irrigation scheduling can then automated, to account for diurnal or seasonal differences in plant water demand

Sensor Performance

— to ensure that we are accurately measuring plant water use

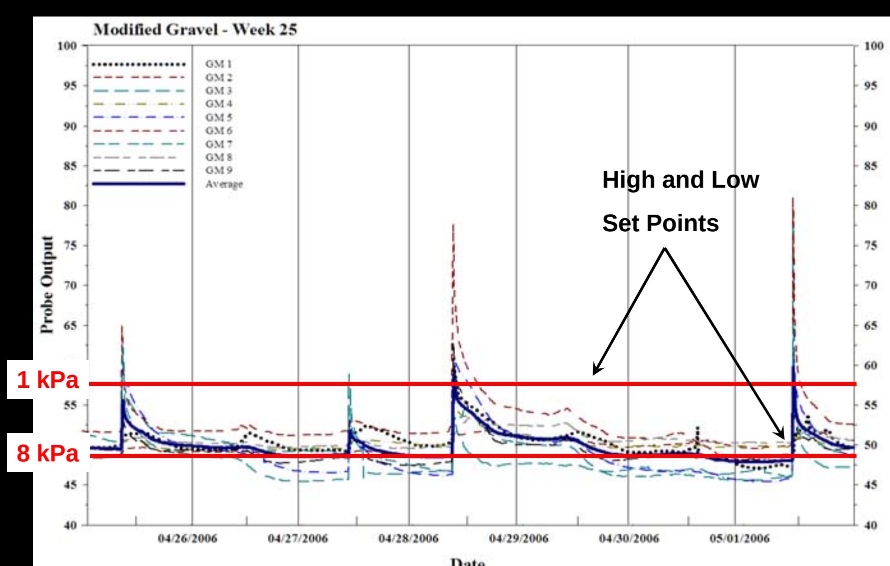
➔ *Calibrate irrigation set points*

to reduce water use and nutrient leaching, without causing water stress

➔ *Accurate placement*

to ensure that the system will measure consumptive use, as the plant grows

Measuring Sensor Variability and Scheduling



In Summary

- Our focus is to develop a robust, cost-effective sensor network for the nursery and greenhouse industry
- We are working directly with producers, to capture production environment data and critical input from the end-user
- We are using the data generated for real-time monitoring and control of irrigation and nutrient applications.
- Sensor performance in both soil and soilless systems is adequate for irrigation management, but issues of sensor placement and spatial and temporal variability need to be addressed