TAES 2007 Report to NCR-101

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1. Research Achievement

TAES – El Paso determined and compared the drought tolerance of four woody ornamental shrubs in the greenhouse and 15 species of herbaceous bedding plants in the field in raised beds. Based on growth and physiological response, relative drought tolerance was determined and species that can be used in hot and dry environment were recommended. Results will be published in referred and trade journals in the near future.

TAES – El Paso determined and compared the salinity tolerance of 10 herbaceous and groundcover species in raised beds in the field and irrigated with controlled salinity levels. Four of the species were used in previous greenhouse studies, which gave relative tolerance among the tested species. The field study further confirmed the salt tolerance of the selected species. In addition, environmental conditions influenced the plant response to salinity and performance under elevated salinity levels. Higher temperature and drought stress exacerbate the salt injury on less-tolerant species.

TAES – College Station has found that: 1) plants grow well under low pressure (25 kPa) compared to ambient (101 kPa) conditions and 2) there is comparable level of CO_2 assimilation (net photosynthesis) and a 25% lower dark respiration rate in low (25/12 kPa pO2) than ambient (101/21 kPa pO_2) pressure plants The considerably lower dark respiration rates (reduced consumption of metabolites) could lead to greater plant growth (biomass production) under low pressure than under ambient conditions during longer crop production cycles. There is also much greater efficiency of photosynthesis/ dark respiration with low pressure plants. Another important finding is that ethylene, which is a trace gas and plant hormone that can cause irregular plant growth and plant sterility, is reduced under low pressure (about 3-fold less). The higher ethylene levels decreased photosynthetic levels of lettuce under ambient conditions (101/ 12 kPa O_2).

2. Impact

TAES – El Paso: Due to limited water supply and rapid increases in urban population, water conservation is becoming increasingly important. Therefore, increasing water use and irrigation efficiency and seeking alternative water sources for urban landscape irrigation and other agricultural use are imperative. Research at the Texas A&M University has shown that use of drought tolerant landscape plants, scheduling irrigation according to actual water needs will greatly contribute to potable water saving. By appropriately selecting salt tolerant plants, reclaimed water, which is municipal effluent, can be used to irrigate landscape plants and hence portable can be conserved.

TAES – College Station: There are advantages in growing plants under hypobaric (reduced atmospheric pressure) conditions in biomass production for extraterrestrial base or spaceflight environments. Elevated levels of the plant hormone, ethylene, occur in enclosed crop production systems and in space-flight environments leading to adverse plant growth and sterility. Objectives of this research are to characterize the influence of hypobaria on growth and ethylene evolution of lettuce (*Lactuca sativa L.* cv. Buttercrunch).

3. Facilities and Equipment

The Texas A&M University Low Pressure Plant Growth (LPPG) system is comprised of six cylindrical polymethyl methacrylate (PMMA) chambers, each fully independent with total pressure, O_2, CO_2, temperature, and relative humidity sensors in each growth chamber. Partial pressures of O2 and CO2 are controlled over a wide range, thus allowing for studies to determine the effects of hypoxia (low O_2) and enhanced CO_2 independent of total pressure, often under hypobaric conditions. Leak rates are very low; less than 1% volume per day. Systems are also in place in each chamber to control water vapor (typically around 85% relative humidity is maintained) and scrub ethylene (C_2H_4). A schematic of a single chamber showing the ethylene filter is shown in figure 1. Temperature control and lighting are provided by a large growth room in the Borlaug Southern Crop Improvement Center at Texas A&M University.

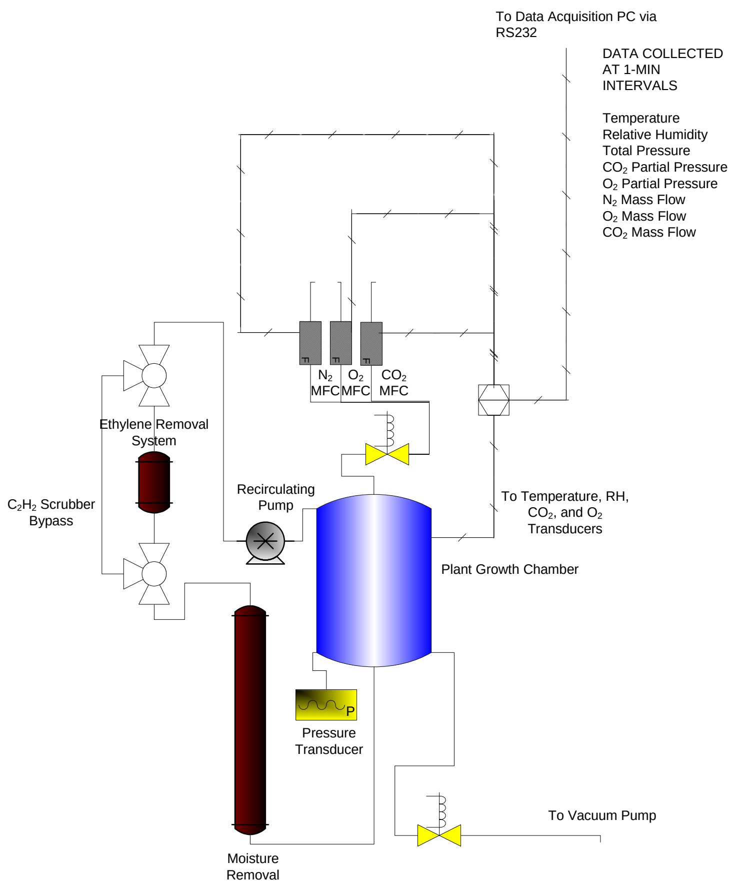

Figure 1. Schematic of single growth chamber showing ethylene filter with bypass (left side of diagram) following the moisture removal system. Air from the chambers is circulated over a cooling coil to remove moisture, through a bed of potassium permanganate pellets to remove ethylene, and returned to the growth chamber. The recirculation pump is a sealed diaphragm type pump.

Sensors and Control Systems

The O_2 sensor is a motion stable, weak acid electrolyte oxygen sensor (MAX-250, Maxtec Inc, Salt Lake City, Utah). This sensor provides a stable signal over an oxygen concentration range of 0 – 100% (0 – 101 kPa partial pressure of O2), will operate for 900,000 hrs, utilizes a non-caustic electrolyte, and is unaffected by acid gases including CO, CO_2, and NO_x. Testing of these sensors in two LPPG chambers has shown them to be reliable over the range of total pressure and O2 partial pressures used in our plant growth experiments. The sensor output is approximately 10 mV DC at ambient O2 partial pressure (20.9 kPa) and must be amplified prior to sending it to an available analog to digital conversion (ADC) channel on the MCU.

The CO_2 sensor utilizes a silicon based non-dispersive infrared (NDIR) technology to optically determine the CO_2 concentration (model GMM222, Vaisala, Helsinki, Finland). The sensor response is converted to a 1 – 5 VDC signal, which is proportional to the CO2 concentration, and sent to another of the available ADC channels on the MCU.

Temperature and relative humidity (RH) are measured with a HT-761 transmitter from Ohmic Instruments, Co. (Easton, MD). This instrument provides two 0 to 1 VDC outputs, proportional to temperature over the range 0 to 100 C and 0 to 100% RH, respectively. Temperature measurement is to a precision of ± 0.3oC and RH is measured to a precision of ± 2%. The conditions in the LPPG chambers are typically between 25 and 35oC and 60 to 85% RH.

The TAMU LPPG utilizes individual PIC16F877 microcontrollers (MCU) (Microchip Technologies, Scottsdale, AZ) for pressure and gas composition control and data acquisition for each growth chamber. The MCU program is written in C and programmed into the MCU using Microchip development tools. Each MCY is polled once a minute over an RS232 interface with a personal computer (PC) running a LabVIEW (National Instruments, Austin, Texas) program that records the data and provides the setpoint values to the MCU.

4. Recent Publications

Referred journal papers

He, C., F. T. Davies Jr. and R. E. Lacey. (2006). Hypobaric conditions affect gas exchange, ethylene evolution and growth of lettuce for advanced life support systems (ALS). *Habitation* **11**: 49-61.

Niu, G. & Rodriguez, D. (2006). Relative salt tolerance selected herbaceous perennials and groundcovers. *Scientia Horticulturae* **110**: 352-358.

Niu, G., Rodriguez, D. & Wang, Y.T. (2006). Impact of drought and temperature on growth and leaf gas exchange of six bedding plant species under greenhouse conditions. *HortScience* **41**(6):1408-1411.

Niu, G. & Rodriguez, D. (2006). Relative salt tolerance of five herbaceous perennials. *HortScience* **41**(6):1493-1497.

Niu, G., Rodriguez, D., Cabrera, R., McKenney, C. & Mackay, W. (2006). Determining Water Use and Crop Coefficients of Five Woody Landscape Plants. *Journal of Environmental Horticulture*. **24**(3): 160-165.

Wang, Y. & Niu, G. (2006). Long-Term growth of live oak propagated from rhizomic shoot cuttings or seeds. *Journal of Environmental Horticulture* **24**:74-76.

Proceedings

Cabrera, R.I., Rahman, R., Niu, G., McKenney, C. & Mackay, W. (2006). Response of containerized herbaceous perennials to salinity stress. Proc. SNA. 51: 81-84.

He, Chuanjiu, Fred T. Davies, Ronald E. Lacey, and Sheetal Rao. (2006). Effect of Hypobaria, Oxygen, and Carbon Dioxide on Gas Exchange, Ethylene Evolution, and Growth of Lettuce Plants for NASA Advanced Life Support Systems. American Society for Horticultural Science meeting in New Orleans, Louisiana.

Lacey, Ronald E., Chuanjiu He, and Fred T. Davies Jr. (2006). Engineering a Low Pressure Plant Growth System – Generation IV. Habitation 2006 meeting in Orlando, Florida.

Lovelady, April, John C. Sager, and Ronald E. Lacey. (2006). Dynamic Low Pressure Gas Mixing. Habitation 2006 meeting in Orlando, Florida.

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Rao, Sheetal, Scott Finlayson, Chuanjiu He, Ronald Lacey, Raymond Wheeler, and Fred T. Davies. (2006). Effect of Hypobaria on the Expression of Ethylene Biosynthesis Genes in Arabidopsis thaliana. American Society for Horticultural Science meeting in New Orleans, Louisiana.

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Cabrera, R.I., & Rahman, L., McKenney, C., Hill, S., Niu, G. & Mackay, W. (2006, April). Evaluating the salinity tolerance of nursery and landscape plants. TNLA Green, 14-18.

Cotton, Susan E. (2006). Outer space researchers say lettuce grows better in less atmospheric pressure. Texas Engineering Communications 2006 [cited February 19 2007]. Available from http://engineeringnews.tamu.edu/news/1348. This story appeared on the *Houston Chronicle* on-line version July 11, 2006.

Niu, G. (2006, September). Salinity tolerance. *American Nurseryman*. 26-29.

Phillips, Kathleen. (2006). Galaxy Gardening More Than Hobby for Future Moon, Mars Residents. Texas A&M University, Agricultural Communications 2006 [cited February 19 2007]. Available from http://agnews.tamu.edu/stories/HORT/Oct0506a.htm. This story appeared on the following web pages: MarsDaily.com, PhysicsOrg.com, ScienceDaily.com, SpaceRef.com, Astrobiology.com, NorthTexas eNews, My Garden Guide, Gardening News, and Texas Gardeners Seeds