Texas AgriLIFE Research 2009 Report to NCERA-101

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1. Impact Nugget

Texas AgriLife Research has demonstrated the potential of higher order plants to provide life support in space missions by successfully growing lettuce at total pressure one-fourth of Earth normal with only one-half of the oxygen and carbon dioxide at levels three to ten times those on Earth.

2. New Facilities and Equipment

A recent project is the design and development of microalgal growth test-bed facilities at Texas A&M University for the production of biodiesel fuels. Six independent mini-racetrack systems (40 L each) have been designed and fabricated to support experimentation of production methods and process control technologies for application to bioenergy research.

3. Unique Plant Responses

Elevated levels of ethylene occur in controlled environment agriculture and in spaceflight environments, leading to adverse plant growth and sterility. The objectives of this research were to characterize the influence of ethylene on carbon dioxide (CO2) assimilation (CA), dark-period respiration (DPR) and growth of lettuce (*Lactuca sativa* L. cv. Buttercrunch) under ambient and low total pressure conditions. Lettuce plants were grown under variable total gas pressures of 25 kPa (hypobaric) and 101 kPa (ambient) pressure. Endogenously produced ethylene accumulated and reduced CA, DPR and plant growth of ambient and hypobaric plants. There was a negative linear correlation between increasing ethylene concentrations [from 0 to around 1000 nmol mol-1 (ppb)] on CA, DPR and growth of ambient and hypobaric plants. Declines in CA and DPR occurred with both exogenous and endogenous ethylene treatments. CA was more sensitive to increasing ethylene concentration than DPR. There was a direct, negative effect of increasing ethylene concentration reducing gas exchange, as well as an indirect ethylene effect on leaf epinasty, which reduced light capture and CA. While the CA was comparable, there was a lower DPR in hypobaric than ambient pressure plants -- independent of ethylene and under non-limiting CO2 levels (100 Pa pCO2, nearly 3-fold that in normal air). This research shows that lettuce can be grown under hypobaria (~25% of normal earth ambient total pressure), however, hypobaria caused no significant reduction of endogenous ethylene production.

The influence of hypobaria and reduced partial pressure of oxygen (pO2) [hypoxia] under low and high light irradiance on carbon dioxide (CO2) assimilation (CA), dark-period respiration (DPR), and the CO2 compensation and CO2 saturation points of lettuce (*Lactuca sativa* L. cv. Buttercrunch) was also evaluated. Plants were grown under variable total gas pressures [25 and 101 kPa (ambient)] at 6, 12 or 21 kPa pO2 (approximately the partial pressure in air at normal pressure). Light irradiance at canopy level of the low pressure plant growth system (LPPG) was at 240 (low) or 600 (high) μmol m-2s-1. While hypobaria (25 kPa) had no effect on CA or the CO2 compensation point, it reduced the DPR and the CO2 saturation point, and increased the CA/DPR ratio. Hypoxia (6 kPa pO2) and low light reduced CA, DPR and the CA/DPR ratio. Hypoxia decreased the CO2 compensation point. Hypoxia also decreased the CO2 saturation point of ambient pressure plants, but had no effect on hypobaric plants. While low light reduced the CO2 saturation point, it increased the CO2 compensation point, compared with high light plants. The results show that hypobaric conditions of 25 kPa do not adversely affect gas exchange compared to ambient pressure plants, and may be advantageous during hypoxia stress.

4. Accomplishment Summaries

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5. Impact Statements

There are important engineering and crop production advantages in growing plants under hypobaric (reduced atmospheric pressure) conditions for extraterrestrial base or spaceflight environments. Advantages include reduced pay load, greater safety because of lower pressure gradients and potentially better plant growth. Objectives of this research were to determine the influence of hypobaria and the partial pressure of oxygen (pO2) on carbon dioxide (CO2) assimilation, dark respiration and growth of higher level plants included in NASA's “salad bowl” program.

6. Published Written Works

He, C., F. T. Davies, and R. E. Lacey. (2009) Ethylene reduces gas exchange and growth of lettuce plants under hypobaric and normal atmospheric conditions." *Physiologia Plantarum* 135(3): 258-71.

Lan, Y., H. Zhang2, R. Lacey, W.C. Hoffmann, W. Wu. Development of an Integrated Sensor and Instrumentation System for Measuring Crop Conditions. (2009) *The Agricultural Engineering International CIGR Ejournal* Manuscript IT-08 1115. Vol. XI: 1-16. April.

Lan, Y. B., Zheng, X. Z., Westbrook, J. K., Lopez, J., Lacey, R. & Hoffmann, W. C. (2008). Identification of stink bugs using an electronic nose. *Journal of Bionic Engineering*, 5, 172-180.

7. Scientific and Outreach Oral Presentations

8. Other relevant accomplishments and activities.