Texas AgriLIFE Research 2008 Report to NCERA-101

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1. New Facilities and Equipment

We continue to maintain and operate the low pressure plant growth (LPPG) system at Texas A&M University. The 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 recent project is the design and development of microalgal growth test-bed facilities at Texas A&M University for the production of biodiesel fuels. These test-beds have the goal of supporting experimentation and scale-up of production methods and process control technologies to full scale facilities.

2. Unique Plant Responses

The objectives of this research were to determine the influence of hypobaria (reduced atmospheric pressure) and reduced partial pressure of oxygen (pO2) [hypoxia] on carbon dioxide (CO2) assimilation (CA), dark-period respiration (DPR) and growth of lettuce (Lactuca sativa L. cv. Buttercrunch). Lettuce 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). Growth of lettuce was comparable between ambient and low total pressure but lower at 6 kPapO2 (hypoxic) than at 12 or 21 kPa pO2. The specific leaf area of 6 kPa pO2 plants was lower, indicating thicker leaves associated with hypoxia. Roots were most sensitive to hypoxia, with a 50–70% growth reduction. Leaf chlorophyll levels were greater at low pressure than at ambient pressure. Hypobaria and hypoxia did not affect plant water relations. While hypobaria did not adversely affect plant growth or CA, hypoxia did. There was comparable CA and a lower DPR in low than in ambient total pressure plants under non-limitingCO2 levels (100 Pa pCO2, nearly three-fold that in normal air). The CA/DPR ratio was higher at low than at ambient total pressure, particularly at 6 kPa pO2 – indicating a greater efficiency of CA/DPR in low-pressure plants. There was generally no significant interaction between hypoxia and hypobaria. We conclude that lettuce can be grown under subambient pressure (~25% of normal earth ambient total pressure) without adverse effects on plant growth or gas exchange. Furthermore, hypobaric plants were more resistant to hypoxic conditions that reduced gas exchange and plant growth.

3. Accomplishment Summaries

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. Scientists at Texas A&M University have worked to characterize the influence of hypobaria and hypoxia on growth and ethylene evolution of lettuce (*Lactuca sativa L.* cv. Buttercrunch) and other “salad bowl” crops. If high ethylene levels can be avoided, low pressures (¼ of earth normal) and oxygen levels down to 12 kPa (½ earth normal) have been shown to have no measurable effect on plant germination and growth.

4. Impact Statements

There are important engineering and cost advantages in growing plants under hypobaric (reduced atmospheric pressure) conditions for extraterrestrial base or spaceflight environments including reduced pay load mass (cost savings), reduced risk of leaks because of lower pressure gradients (crew safety), and reduced need for make-up gases and materials (cost savings). At Texas A&M University we are working to determine the influence of low total pressure (hypobaria) and reduced 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. Results suggest that plants can be successfully germinated and grown at pressures ¼ of earth normal and at pO2 at ½ of earth normal.

5. Published Written Works

Huang, Y.; Lan, Y.; Hoffmann, W. C. & Lacey, R. E. (2007), Multisensor Data Fusion for High Quality Data Analysis and Processing in Measurement and Instrumentation, *Journal of Bionics Engineering* **4**.

He, C. J.; Davies, F. T.; Lacey, R. E. & Rao, S. (2007), The influence of ethylene and hypobaria on CO2 assimilation, dark-period respiration, and growth of lettuce (Lactuca sativa L. cv. buttercrunch), *Hortscience* **42**(4), 994--994.

He, C. J.; Davies, F. T. & Lacey, R. E. (2007), Separating the effects of hypobaria and hypoxia on lettuce: growth and gas exchange, *Physiologia Plantarum* **131**(2), 226—240.

6. Scientific and Outreach Oral Presentations

Huang, Y.; Lan, Y.; Hoffmann, W. & Lacey, R. E. (2007), Enhancement of Data Analysis through Multisensor Data Fusion Technology"ASABE Annual Meeting.

7. Other relevant accomplishments and activities.