NCERA-101 STATION REPORT FROM KENNEDY SPACE CENTER, FL, USA (Sept. 2012)

Impact Nugget:

A small plant growth chamber called "VEGGIE", for growing vegetables on the International Space Station is being built by ORBITEC, Madison, WI and is scheduled for a space flight demonstration beginning in Aug 2013. KSC and ORBITEC will team up to conduct a verification experiment to grow lettuce on the International Space Station.

Facility Description:

The Space Life Sciences Lab (SLSL) Controlled Environment Lab (CEL) has been operational for 9 ½ years (commissioned Sept. 2003) and provides 622+ ft^2 (58 m^2) of controlled environment chamber space. The CEL provides support to both basic and applied research with emphasis on ground-based and space applications. Redundant to local chamber environmental control, the laboratory has developed and maintained a centralized command, monitoring, and data system (CMDS) with an associated database and alarming capabilities. The CEL is used to support the needs of a variety of scientific research areas including NASA, private industry, and academia. NASA has returned operations of the SLSL to Space Florida, the agents representing the State of Florida. The NASA-related research at the SLSL is being managed under Engineering Services Contract (ESC), with QinetiQ-North America as the prime contractor.

Currently, Kennedy Space Center (KSC) management is looking at moving the biological research group from the Space Life Sciences Lab (SLSL) to some other facility on the main part of KSC. Whether we would continue to use the growth chambers in the SLSL building, or move some chambers to another facility is still to be determined. Stay tuned for further developments from Florida.

New Equipment / Sensors / Control Systems:

- We received and have been testing 12 "UFO" red/blue LED lighting fixtures (50 W each) as part of growing plants in a human habitation testbed, called the Habitation Demonstration Unit or HDU. The crops were grown in an "atrium" surrounding a lift that went between the lower and upper modules of the HDU. The fixtures were purchased from AIBC Intl., Ithaca, NY Office, USA. Measurements using an integrating sphere showed the fixtures were approximately 25% efficient (i.e., 25 W of PAR from 100 W of electric power).
- We also received 10 custom-built, white LED flat panel lighting fixtures from AIBC. The thin panels are dimmable and can provide approximately 300 µmol m^{-2} s^{-1} at 6 inches (15 cm) below the panel. The panels will be tested in 2012 in the same human habitation module as the red/blue UFO fixtures in 2011.
- We received 16 red/blue/green smart LED High Efficiency Lighting with Integrated Adaptive Control or HELIAC "Lightsicles" from ORBITEC, Madison, WI, USA. These linear LED arrays were built on a Small Business Innovative Research grant from NASA and tested at Purdue University for intra-canopy lighting applications whit plant detection capabilities. The Lightsicles can also be configured as a flat panel array for overhead lighting.
- We received seven small LED units from ORBITEC to conduct light transmission studies. Lights wavelengths are: 400, 450, 530, 595, 630, 655 and 735 nm. Testing with several plant species growing under high and low light levels is underway.

Unique Plant Responses:

- Barrel medic (*Medicago truncatula*) seedlings were flown on Space Shuttle flight STS-135 on a sortie mission to the International Space Station. Some seedlings were inoculated with nitrogen fixing bacteria (*Sinorhizobia meliloti*) to assess whether early events of nodulation would occur in space. Specific markers for infection and initial events of nodulation showed a positive response, but no nodules formed in the dark-grown seedlings. Gary Stutte and Mike Roberts hope to follow this up with a study where seedlings could be grown in a plant chamber with lighting to speed growth and promote more rapid development of nodules.

Accomplishments:

- Completed the second operational field testing of the food production called the plant atrium in the Habitat Demonstration Unit (HDU) at NASA's Desert Research and Technology Studies (Desert RATS) program in Aug.-Sept. 2011. Lettuce, mizuna, basil, radish, and sweetpotatoes were grown under red/blue LED lighting for the 2-week duration of the test.

- Continued testing passive water and nutrient delivery system for microgravity to support salad crop production in space using ORBITEC's VEGGIE plant growth unit. We designed and tested plastic packets or "pillows" containing media and time-release fertilizer with a wicking surface to directly transfer water from the VEGGIE reservoir. Lettuce, mizuna, pea, radish, and several species of herbs all grew well in pillows of both arcillite and peat-based media. Additional testing with spaceflight qualified materials is underway.

Impact Statements:

- For a second year, NASA KSC has demonstrated salad crop production using realistic environmental constraints in a simulated outpost as part of NASA's Deep Space Habitat project. The crew responded positively to having plant present in the habitat and unexpectedly consumed some of the plants (we weren't planning this!).

Recent Publications/Presentations:

Wheeler, R.M., C.A. Wehkamp, M.S. Stasiak, M.A. Dixon, and V.Y. Rygalov. 2011. Plants survive rapid decompression: Implications for bioregenerative life support. Adv. Space Res. 47:1600-1607.

Hummerick, M.E., J. Garland, and R. Wheeler. 2011. A hazard analysis critical control point plan applied to the Lada vegetable production units ((PU) to ensure the safety of space grown vegetables. Amer. Inst. Aeronautics Astronautics, AIAA-2011-5277, 41st ICES meeting, Portland, Oregon.

Stutte, G.W., G. Newsham, R.C. Morrow and R.M. Wheeler. 2011. Operational evaluation of VEGGIE food production system in the habitat demonstration unit. Amer. Inst. Aeronautics Astronautics, AIAA-2011-5262-575, 41st ICES Mtg., Portland, Oregon.

Stutte, G.W., G. Newsham, R.C. Morrow, and R.M. Wheeler. 2011. Concept for sustained plant production on ISS using VEGGIE capillary mat rooting system. Amer. Inst. Aeronautics Astronautics AIAA-2011-5263-523, 41st ICES, Portland, Oregon.

Hummerick, M.P., J. Gates, B-T. Nguyen, G.D. Massa and R.M. Wheeler. The effect of plant cultivar, growth media, harvest method and post harvest treatment on the microbiology of edible crops. Amer. Inst. Aeronautics Astronautics, AIAA 2012-3506, 42nd ICES, San Diego, CA.

Levine, LH, J.L. Coutts, J.T. Richards, P.E. Hintze, and C.A. Clausen 2012. Review on transforming TiO_2 into a visible-light- responsive catalyst for water and air purification. Amer. Inst. Aeronautics Astronautics, AIAA 2012-3629, 42nd ICES, San Diego, CA.

Downey, P.J., L.H. Levine, M.E. Musgrave, M. McKeon-Bennett, and S. Moane. 2012. Effect of hypergravity and phytohormone on isoflavonoid accumulation in soybean (*Glycine max* L.) callus. Microgravity Sci. Technol. DOI 10.1007/s12217-012-9322-9

Kaplan, F., W. Zhao, J.T. Richards, R.M. Wheeler, C.L. Guy and L.H. Levine. 2012. Transcriptional and metabolic insights into the differential physiological responses of Arabidopsis to optimal and supraoptimal atmospheric CO_2. PLOS ONE 7(8):e43583.

Scientific Outreach:

Committees / Panels:

ASHS CE Working Group (Stutte, Wheeler, Massa)
Intl. Advanced Life Support Working Group (Wheeler)
Com. on Space Research (COSPAR) F4 (Wheeler)
ACMAP Board of Directors (Stutte)
ASGSB Governing Board (Massa)

Sabbatical Leave

Gary Stutte, Marie Curie Fellowship from EU
(working at Limerick Institute of Technology, IE)