NCERA-101 STATION REPORT FROM KENNEDY SPACE CENTER, FL, USA (April 2011)

Impact Nugget:

A small scale salad production system using LED light source was incorporated into NASA's Habitat Demonstration Unit testing of surface systems.

Facility Description:

The Space Life Sciences Lab (SLSL) Controlled Environment Lab (CEL) has been operational for 8 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 requirements 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 Life Sciences Services Contract (LSSC) at Kennedy Space Center, under which Dynamac Corporation managed the laboratories and implemented NASA life science research, ended February 28, 2011. The operation of the SLSL has been incorporated in the Engineering Services Contract (ESC), with QuineQ-NA the prime contractor.

New Equipment / Sensors / Control Systems:

- The primary control and monitoring system for the CEL, CMDS [Command, Monitoring and Data System], is being maintained, and opportunities to expand implementation across NASA ESC labs are being reviewed.
- Continued testing and use of a high output LED array from ORBITEC with >300 μmol m^{-2} s^{-1} PPF @ each of six wavelengths (400, 440, 520, 640, 660, and 730 nm).
- A vacuum chamber for lunar and Mars dust/regolith testing continues to operate and can provide 10^{-7} Torr capability (hard vacuum).
- ORBITEC developed a second generation "VEGGIE" units (Phase II SBIR grant from NASA) as a deployable plant growth system for producing salad type crops. The VEGGIE design provides growing areas that can be "daisy chained" together to provide approximately a one m^2 growing area (6 VEGGIE units) and can be stowed within a single crew transfer bag on the Space Shuttle. The VEGGIE units provide LED lighting and a water/nutrient delivery matting, but utilize the cabin environment for temperature and CO2 control to minimize complexity and power requirements. The second generation VEGGIE uses high-intensity discrete LEDs rather than the light engines on earlier generation. In addition the fans and bellows attachment differ. VEGGIE has gone through a preliminary flight hardware readiness evaluation.
- Small (15.4 cm diameter) and large (26.7 cm diameter) 50 W commercial, off the shelf (COTS) LED "UFO" plant lights were characterized for use in the 2011 Habitat Demonstration Unit (HDU) plant atrium. Lamps consisted of 630 nm red and 460 nm blue LEDs with the smaller unit having 44 red and 6 blue while the larger unit had 43 red and 5 blue. The larger unit had 40% greater PAR output and greater uniformity than the smaller unit. The larger unit was chosen for the plant atrium, however when a batch of units was obtained these had different characteristics than the original test unit and the LED ratio changed to 42 red to 6 blue. Uniformity within the batch was high with less than 4% variability between lamps. The HDU plant atrium will consist of eight plant growth units of lamps and trays arranged around a crew transport lift between the lab portion and the second story habitation portion of the HDU. COTS trays and custom reservoirs and lids will support passive hydroponic plant growth.
- Continued to maintain a "Lighting Testbed" with the addition of a 1-m integrating sphere and an Optronics spectroradiometer with spectral range in the visible and near IR (380 to 1180 nm) to obtain spectral power distributions and total lumen outputs as well as a goniometer to obtain lamp distribution characteristics.

Unique Plant Responses:

- *S. meliloti* infection, and induction of early steps of nodulation, has been demonstrated in dark grown *M. truncatula* seedlings.
- Beet plants growing under 24-hr compact fluorescent light showed extreme foliar stress including red pigmentation, leaf curling, brittleness, and necrosis.

Accomplishments:

- Completed initial operational field testing of the food production system with VEGGIE LED light cap for NASA in the HDU in the Desert Research and Technology Studies (Desert RATS) program in Aug.- Sept. 2010. Lettuce was grown, harvested, sanitized and consumed by crew members in the test. Testing of additional species for the 2011 HDU field test is underway.
- Continuing to develop protocols for passive water and nutrient delivery system in microgravity to support salad crop production in microgravity using Orbitec's VEGGIE LED light source and passive environmental control system. Have designed and tested a "pillow" concept containing media and time-release fertilizer with a wicking surface to directly transfer water from the VEGGIE reservoir through capillary wicking. Lettuce grew well in pillows of both arcillite and peat-based media. Further pillow, species, and media testing is underway.
- Developing protocols for experiment to determine the effect of microgravity on plant/microbe interactions in the using *the Medicago truncatula: Sinorhizobia meliloti* model system for an experiment on the STS-135, the final flight of the Space Shuttle Atlantis.

Impact Statements:

- NASA KSC has demonstrated that the bioprotective value of salad crops, which have potential as a biological countermeasure to radiation on long-duration space missions, can be significantly increased by the selective application of blue or UV light to regulate plant morphology and anthocyanin synthesis.
- NASA KSC has demonstrated salad crop production using realistic environmental constraints in a simulated lunar outpost as part of the 2010 Desert RATS operational field test. Response to salad production was positive and crop production will have larger area for participation in the 2011 NASA Desert RATS field test.

Recent Publications/Presentations:

Hummerick, M.E., J. Garland, G. Bingham, V.N. Sychev, and I.G. Podolsky. 2010. Microbiological analysis of Lada vegetable Units (VPU to define critical control points and procedures to ensure the safety of space grown vegetables. Amer. Inst. Aeronautics Astronautics (ICES 2010, Barcelona).

Stutte, G.W., S. Edney and G. Newsham. 2010. Effects of UV light on anthocyanin content of red leaf lettuce under narrow and broad band light sources. Proc. Plant Growth Reg. Soc. Amer. 36: 121-127

Takeda, F., D.M. Glenn, A. Callahan, J. Slavin and G.W. Stutte. 2010. Delaying flowering in short-day strawberry transplants with photoselective nets. Intern. J. Fruit Science 10: 134-142.

Wheeler, R.M. 2010. Plants for human life support in space: From Myers to Mars. Gravitational and Space Biology 23(2):25-35.

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.

Scientific Outreach:

Committees / Panels:

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

Visiting Researchers:

Gioia Massa, NASA Postdoctoral Fellow