NCR-101 STATION REPORT FROM KENNEDY SPACE CENTER, FL, USA (March 2004)

New Facilities:

The move from Hangar L to the facility called the new Space Life Sciences Lab (SLS Lab), previously the Space Experiment Research and Processing Laboratory, was completed in October 2003. The SLS Lab is a three story 100,000 ft^2 (965 m^2) facility. The phytotron area consists of a controlled environment chamber lab, control room, nutrient preparation lab, harvest lab, and biomass processing labs that occupy 10381ft^2 (290m^2) of the total facility. We moved two EGC model M-48, two M-12, and two GC-15 chambers from Hangar L to the new facility. In addition, we purchased five EGC model M-48, two M-12, and four GC-36 chambers. All 17 chambers were fitted with PP Systems WMA-4 CO_2 analyzer / controllers and EGC TC-2 control systems. Three of the new M-48 chambers have dual HPS / fluorescent (VHO) lamp capabilities, with dimming ballasts and feedback control for the HPS lamps. The new M-12 and GC-36 chambers have T5 fluorescent lamps with electronic, dimming ballasts. The new M-12 chambers have an additional feedback PPF control feature. The other two new M-48 chambers have fluorescent (VHO) canopies and chemical drying systems for humidity control that will be used to provide analogous environments of both shuttle and space station to support ground controls of spaceflight experiments.

Equipment / Sensors / Control Systems:

- A control and monitoring system, CMDS [Command, Monitoring and Data System (formerly SAGERS)], is nearing completion and will provide monitoring and control functions to each growth chamber and other experimental equipment (e.g. bioreactors). In addition, the system will monitor and alarm critical equipment in the facility (e.g. freezers, incubators). The CMDS uses OPTO Snap/Ethernet input and output modules, the MS Windows O/S, a CITRIX secure web-based interface for configuring equipment, user set points and data queries, and an MS SQL database for storing collected information. The CMDS interfaces with and utilizes the EGC TC-2 controllers for backup in case of failure.
- Testing continued with red and blue LEDs arrays as sources for plant lighting. In addition, we purchased some green fluorescent lamps and some combination "RGB" LED arrays from Norlux Corp. to provide supplemental green light to the plants. This might create a more "acceptable" light environment for humans to monitor and maintain plants.
- Ground-based testing continued with porous tube watering systems for spaceflight. The tubes are either porous stainless steel or ceramic, which is naturally hydrophilic. An upcoming spaceflight experiment (tentatively May 2005) will study plant growth using both porous tubes directly as a rooting surface and in combination with a solid medium of arcillite (calcined clay particles) where the tubes are used to subirrigate the medium.
- A volatile organic compound analysis (VOCA) system is being designed to determine the threshold of biogenic gas activity on plant growth and development The VOCA will be used to establish VOC recommendations for an atmospheric filtering system during spaceflight missions.

Unique Plant Responses:

- VOC exposure studies with radish were conducted to determine response thresholds for ethylene, ethanol, toluene and acetone. Response threshold to ethylene was less than 40 ppb. Adverse responses to ethanol were observed at ~ 0.5 of the recommended Spacecraft maximum allowable concentration (SMAC).
- Wheat from an experiment on the Intl. Space Station was ~ 10% taller under microgravity conditions, but there was no difference in stand gas exchange or total biomass. Changes in chloroplast structure were observed. Differences in plant height could not be explained by either the slightly higher root zone temperatures in space or potential differences in canopy boundary layers in microgravity.
- Radish, lettuce, and onion plants were grown in mixed plantings using recirculating hydroponic systems under CWF lighting and 1200 CO_2. No significant differences were observed for lettuce and onion compared to monoculture systems, however radish showed slightly increased yield compared to mixed plantings. We attributed this to earlier canopy development for radish in multi-species plantings.
- Environmental baseline studies for typical open Intl. Space Station cabin atmosphere were performed with radish, lettuce, and onion. Treatments included ambient and elevated CO_2 (400 and 1200 ppm), PPF levels of 150, 300, and 450 _mol m^{-2} s^{-1}, air temperature of 25 C and a 16-h photoperiod with fluorescent lamps. We plan to finish the studies with 4000 ppm CO_2 and air temperatures of 22 and 28 C.
- Cultivar evaluations with dwarf tomato and pepper were initiated. Early observations indicate that cv. Triton pepper develops extensive oedema (intumescence) on leaves (CWF lamps with an acrylic barrier used).
- Cultivar evaluations with red leafed and Romaine type lettuce were initiated. Cv. Eruption showed the deepest red coloration in comparison to cvs. Outredgeous and Red Sails when grown under CWF at 300 _mol m^{-2} s^{-1}.

Committees / Panels:

ASHS Plant Biology Working Group (Stutte)
ASHS Publications Committee (Stutte)

ASHS CE Working Group (Stutte, Yorio, Wheeler)
Plant Growth Regulator Society of America Steering Com. (Stutte)
Intl. Advanced Life Support Working Group (Sager, Wheeler)

Visiting Scientists:

Hyeon-Hye Kim, Michigan State Univ.; NASA-National Research Council Fellowship
Michelle McKeon, Limerick University, Limerick, Ireland
Garth Munz, University of Guelph, Ontario
Jun Eek Son, Seoul National University, Seoul, South Korea

Recent Publications:

Eraso, I. and G.W. Stutte. 2003. Cultivar effects on radish sensitivity/resistance to chronic ethylene exposure. Proc. Plant Growth Reg. Soc., 30th Ann. Mtg., Vancouver, Aug. 2003, pp. 152-158.

Frazier, C.M., J.B. Simpson, M.S. Roberts, and G.W. Stutte. 2003. Bacterial and fungal communities in BPS chambers and root modules. SAE Technical Paper 2003-01-2528.

Goins, G.D., N.C. Yorio, G.W. Stutte, R.M. Wheeler and J.C. Sager. 2003. Baseline environmental testing of candidate salad crops with horticultural approaches and constraints typical of spaceflight. SAE Technical Paper 2003-01-2481.

Goins, G.D., N.C. Yorio, and R.M. Wheeler. 2004. Influence of nitrogen nutrition management on biomass partitioning and nitrogen use efficiency in hydroponically-grown potato. J. Amer. Soc. Hort. Sci. 129:134-140.

Levine, L.H., H. R. Kagie and J. L. Garland. 2003. Biodegradation pathway of an anionic surfactant (Igepon TC-42) during recycling waste water through plant hydroponics for advanced life support during long-duration space missions. Adv. Space Res. 31(1):249-253.

Levine, H.G., G.K. Tynes and J.H. Norikane. 2003. Fluid behavior under microgravity conditions within plant nutrient delivery systems: Parabolic flight investigations. SAE Tech. Paper No. 2003-01-2483..

Levine, H.G., D.T. Rouzan and J.H. Norikane. 2003. Evaluation of a Pulse Fertilization Strategy for the Cultivation of Plants in Space. SAE Tech. Paper No. 2003-01-2615. 33rd ICES. Vancouver, BC. July 2003.

Mathieu, J.J. and J.C. Sager. 2003. Computer control system for Kennedy Space Center's New Biological Sciences research facility: Space Experiment Research and Processing Laboratory (SERPL). Amer. Soc. Agric. Eng. Mtg. Paper 034068.

Monje, O., G.W. Stutte, G.D. Goins, D.M. Porterfield, and G.E. Bingham. 2003. Farming in space: Environmental and biophysical concerns. Adv. Space Res. 31(1):151-167.

Norikane, J.H., G.K. Tynes, and H.G. Levine. 2003. Determining the extractable water limit for wheat in a substrate-based media designed for space flight applications. Trans. Amer. Soc. Ag. Eng. 19:565-569.

Norikane, J.H., S.B. Jones, S.L. Steinberg, H.G. Levine, and D. Or. 2003. Effects of variable gravity on porous media matric potential and water content measurements. Amer. Soc. Ag. Eng. Mtg. Paper 034067.

Norikane, J., E. Goto, K. Kurata and T. Takakura. 2003. A new relative referencing method for crop monitoring using chlorophyll fluorescence. Adv. Space Res. 31(1):245-248.

Schuerger, A.C., G.A. Capelle, J.A. Di Benedetto, C. Mao, C.M. Thai, M.D. Evans, J.T. Richards, T.A. Blank, and E.C. Stryjewski. 2003. Comparison of two hyperspectral imaging and two laser-induced fluorescence instruments for the detection of zinc stress and chlorophyll concentration in Bahia grass (*Paspalum notatum* Flugge). Remote Sensing of Environment 84:572-588.

Stutte, G.W., O. Monje, and S. Anderson. 2003. Wheat (Triticum aestivum L. cv. USU Apogee) growth onboard the International Space Station (ISS): germination and early development. Proc. Plant Growth Reg. Soc., 30th Ann. Mtg., Vancouver, Aug. 2003, pp. 66-71.

Subbarao, G.V., O. Ito, W.L. Berry, R.M. Wheeler. 2003. Sodium - A functional plant nutrient. Critical Reviews in Plant Sciences 22 (5): 391-416.

Wheeler, R.M. 2003. Carbon balance in bioregenerative life support systems: Effects of system closure, waste management, and crop harvest index. Adv. Space Res. 31(1):169-175.

Wheeler, R.M., C.L. Mackowiak, G.S. Stutte, N.C. Yorio, L.M. Ruffe, J.C. Sager, R.P. Prince, B.V. Peterson, G.D. Goins, W.L. Berry, C.R. Hinkle, and W.M. Knott. 2003. Crop production for Advanced Life Support Systems. Observations from the Kennedy Space Center Breadboard Project. NASA/TM–2003-211184.

Yorio, N.C., G.D. Goins, R.M. Wheeler, and G.W. Stutte. 2003. Regulation of biomass partitioning in hydroponically-grown potato by altering nitrogen concentrations. Proc. Plant Growth Reg. Soc. 30th Ann. Mtg., Vancouver, Aug. 2003. pp. 163-168.

Website:

Advanced Life Support Crop Research: http://advlifesupport.jsc.nasa.gov/Crops/index.html