NCR-101 STATION REPORT FROM KENNEDY SPACE CENTER, FL, USA (APRIL 2003)

New Facilities:

- We are preparing to move from Hangar L to a new facility called the Space Experiment Research and Processing Laboratory (SERPL). We will move two EGC model M-48 (walk-in), two M-12, and 2 GC-15 chambers from Hangar L to the new facility. In addition, we will purchase five EGC model M-48, two M-12, and four GC-36 chambers. The new M-48 chambers will have dual HPS / fluorescent (VHO) lamp capabilities, with dimming ballasts for the HPS lamps. The new M-12 and GC-36 chambers will have T5 lamp fluorescent lamps with electronic, dimming ballasts. Two of the new M-48 chambers will be used to provide analog environments of both shuttle and space station to support ground controls of spaceflight experiments.

Equipment / Sensors / Control Systems:

- A control and monitoring system called SAGERS (SERPL Autonomous Ground Equipment Regulation System) is currently under development and will replace the computer control system that has been used in Hangar L for many years. The system 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). SAGERS will use OPTO Snap/Ethernet input and output modules, Linux-based software, and the system will have a secure web-based interface for configuring equipment, user set points and data queries, as well as a database for storing collected information.
- A number of environmental sensors tests were conducted at different atmospheric pressure to study low pressure greenhouse concepts for space. Capacitance type humidity sensors (e.g., Vaisala) and a dewpoint device tracked closely across a range of pressures (~10 kPa to 101 kPa), but a wet / dry bulb psychrometer showed increased WB depressions as pressure decreased. This was likely due to increased gas diffusion (and evaporation) rates at the lower pressures. A Vaisala CO_2 sensor held up well at reduced pressures but it (and very likely other IRGAs) will need to be calibrated at each target pressure due to offset differences in band broadening. We are hoping to compare galvanic and fluorescence type O_2 sensors at different pressures.
- As part of the pressure tests, it was interesting to observe the saturation pressure of water is essentially independent of total pressure. Thus at a constant temperature, similar relative humidities represent similar partial pressures regardless of the total pressure.
- 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 test stand for studying the effects of volatile organic compounds (VOCs) on plant growth and development is being developed. These will be used to establish VOC thresholds for an atmospheric filtering system being developed for an upcoming spaceflight experiment.

Unique Plant Responses:

- PESTO wheat experiment was conducted for 73 days on board the Intl. Space Station. This experiment characterized the effects of microgravity conditions on stand level gas exchange and carbon partitioning, and indicated that stand photosynthesis and transpiration rates were not reduced in microgravity. Microgravity effects on chloroplast morphology, PSII, PSI, and whole chain electron transport systems also were observed.
- CO_2 experiments with radish and lettuce continued over the past year. We are still interested in the plant responses to “super-elevated” CO_2 concentrations (e.g., 4000 ppm and greater) that are encountered in tightly closed space systems, like the International Space Station.
- A series of nitrogen nutrition tests were completed last year with potatoes grown in recirculating NFT. Results showed that dropping the nitrate concentration from 7.5 to 1.0 mM at 42 DAP produced equivalent tuber yields with less vegetative growth. Dropping the total EC of the solution from 1.2 to 0.3 dS m^{-1} had similar effect but tuber yields were significantly less than control plants.
- Tests in which potatoes and wheat were grown simultaneously in the same chamber but with different photoperiods resulted in poor tuber formation on the potatoes. This led to a series of tests to study thresholds of night irradiance for delaying tuberization. Results showed tuberization of cv. Norland was delayed if a

continuous night irradiance exceeded ~2-3 μmol m^{-2} s^{-1}, while cv. Russet Burbank were more sensitive with tuberization delayed when levels exceeded 0.4 μmol m^{-2} s^{-1}. (Full moon light is ~0.01 μmol m^{-2} s^{-1}).

- Radish and onion plants were grown in recirculating hydroponic systems using either CWF or HPS lighting. Plant biomass was slightly greater under HPS lighting, but differences were not significant.
- Eight cultivars of bunching onion (*Allium fistulosum*) and eight cultivars of radish (*Raphanus sativus*) were compared for performance in a recirculating NFT system. Data on yields, size, and general acceptability were gathered in these tests and will be used to assess the cvs. for use in spaceflight systems.

Committees / Panels:

ASHS Plant Biology Working Group (Stutte)
ASHS CE Working Group (Stutte, Yorio, Wheeler)
Plant Growth Regulator Society of America Steering Com. (Stutte)

Visiting Scientists:

Mike Dixon, University of Guelph; 6 mo. sabbatical and NASA-National Research Council Fellowship
Yuli Berkovich, Inst. of Biomedical Problems, Moscow; NASA-National Research Council Fellowship
Hyeon-Hye Kim, Michigan State Univ.; NASA-National Research Council Fellowship
Katsumi Ohyama, Chiba University, Japanese Society for Promotion of Science Fellowship
Jennifer Mathieu, Cornell University, NASA Graduate Student Fellowship
Bashnaib Tripathy, Jawaharlal Nehru Univ, New Dehli, NASA-NRA Grant

Recent Publications:

Berkovich, Yu. A., G.K. Tynes., J.H. Norikane, and H.G. Levine. 2002. Evaluation of an ebb and flow nutrient delivery technique applicable to growing plants in microgravity. SAE Tech. Paper No. 2002-01-2383.

Burtness, K., K. Norwood, T. Murdoch and H.G. Levine. 2002. Development of a porous tube based plant growth apparatus. SAE Tech. Paper No. 2002-01-2389.

Ciolkosz, D.E., L.D. Albright, J.C. Sager, and R.W. Langhans. 2002. A model for plant lighting system selection. Transactions of the ASAE 45:215-221.

Corey, K.A., D.J. Barta, and R.M. Wheeler. 2002. Toward Martian agriculture: Responses of plants to hypobaria. 2002. Life Sup. Biosphere Sci. 8:103-114.

Ferl, R., R.M. Wheeler, H.G. Levine, and A.L. Paul. 2002. Plants in space. Cur. Opin. Plant Biol. 5:258-263.

Goins, G.D. 2002. Growth, stomatal conductance, and leaf surface temperature of Swiss chard grown under different artificial lighting technologies. SAE Tech. Paper 2002-01-2338.

Levine, H.G., G.K. Tynes, J.H. Norikane and K. Burtness. 2002. Evaluation of alternative water input modes for space-based plant culture applications. SAE Tech. Paper No. 2002-01-2381.

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.

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., 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.

Norikane, J.H., G.K. Tynes, C.M. Frazier and H.G. Levine. 2002. Comparison of two alternative soil moisture sensor designs for spaceflight applications. SAE Tech. Paper No. 2002-01-2385.

Rygalov, V.Ye., R.A. Bucklin, A.E. Drysdale, P.A. Fowler, and R.M. Wheeler. 2002. Low pressure greenhouse concepts for Mars: Atmospheric composition. SAE Tech. Paper 2002-01-2392.

Stryjewski, E., I. Eraso and G. Stutte. 2002. Leaf anatomy of *Raphanus sativus* exposed to space Shuttle/ISS temperature profiles. SAE Tech. Paper 2002-01-2387.

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.

Yorio, N.C., S.L. Edney, O.A. Monje, I. Eraso, G.W. Stutte, R.M. Wheeler. 2002. Comparison of radish growth under HPS and cool-white fluorescent lamps. 2001 Proc. Plant Growth Reg. Soc. Amer. pp. 113-117.

Website:

KSC life science research activities: http://bioscience.ksc.nasa.gov/oldals/index.html