NCR-101 STATION REPORT FROM KENNEDY SPACE CENTER, FL, USA (APRIL 2002)

New Facilities:

- Foundations, connecting roads, and utilities are being laid for the new life sciences research facility at Kennedy Space Center, FL. The building is funded by the State of Florida and will functionally replace Hangar L. Tentatively, six of the older growth chambers at Hangar L will be moved to the new building, while the remaining nine will be replaced with new chambers. We also hope to purchase two hypobaric chambers (Univ. of Guelph design) to accommodate low pressure studies and ground controls for missions that include drops in cabin pressure. *(Shuttle missions with space walks drop cabin pressure to ~ 2/3 atm for several hours prior to the walk).* The Univ. of Florida has established a research and education center (SABRE) to focus space biotechnology and help administer the new facility.

Equipment / Sensors / Control Systems:

- The large Biomass Production Chamber at Hangar L that operated since 1987 was de-commissioned this past year. The chamber provided 20 m^2 growing area in a closed 113 m^3 volume, and served as a test-bed for NASA's CELSS and Advanced Life Support (ALS) Programs. Tests included biomass production and gas exchange studies with hydroponically grown wheat, soybean, potato, lettuce, tomato, and rice.
- The Biomass Production System (BPS) spaceflight chamber was recently launched to the Intl. Space Station (ISS). The BPS is NASA's newest plant chamber for spaceflight research and was developed by Orbitec Corp. (Madison, WI, USA) through a Small Business Innovative Research (SBIR) grant. The current study will track photosynthetic gas exchange of wheat plants in space and is the first plant research project for the ISS (Gary Stutte, KSC, PI).
- Several types of root-zone O_2 and water sensors have been tested for possible use in space. Providing adequate and uniform supplies of water and O_2 to plant roots in weightlessness is difficult, and reliable monitoring techniques are needed. The water sensors operate on a heat pulse dispersion principle and the O_2 sensors use electro-chemical / galvanic principle.
- Testing continued with LEDs arrays as sources for plant lighting. The arrays were built by Quantum Devices (Barneveld, WI, USA) and include red (660, 670, 680, or 690 nm) and blue (470 nm) LEDs. We are hoping to purchase and test high-output red, green, and blue LEDs developed by Norlux Corp. (Carol Stream, IL, USA)
- Ground-based testing continued with porous tube watering systems for spaceflight. An upcoming spaceflight experiment (tentatively 2004) will study plant growth using both porous tubes directly and in combination with a solid medium of arcillite (calcined clay particles).
- Different gauge thermocouples were compared with and without radiation shielding at different atmospheric pressures for possible space applications. Results showed that radiant heating errors increase at low pressures, presumably from reduced convective heat dissipation. Initial tests with wet/dry psychrometers indicate that wet bulb depressions increase at low pressures, presumably from increased gas diffusion and evaporation rates.
- Recent equipment purchases: LICOR LI-6400 portable photosynthesis unit with fluorometer attachment; LI-180012S external integrating sphere; Apogee IRTSP-P infrared transducers.

Unique Plant Responses:

- A series of CO_2 experiments was completed with three different species. CO_2 concentrations up to 16,000 ppm with bean and 15,000 for lettuce and radish resulted in increased water use relative to 1200 ppm. We still do not understand the mechanism causing increased stomatal conductance and transpiration at super-elevated CO_2 concentrations.
- Shoot growth of radish, lettuce, and spinach tended increase under 680 and 690 nm LEDs than 660 nm LEDs. The increased far-red radiation in the 680s and 690s appears to promote leaf stretching / expansion, thereby increasing light interception early in growth. Results still suggest that plants grown under red LEDs require some blue light (~30 μmol m^{-2} s^{-1}) for acceptable growth.
- A series of tests identified four radish cultivars that were tolerant of temperatures up to 30°C. Cv. 'Sora' was selected from them for use on an upcoming space flight experiment because of its uniform germination, heat tolerance, growth rate, and flavor.
- Tests were initiated to look at radish and onion growth in recirculating hydroponic systems using either CWF or HPS lighting. The tests are part of NASA redirecting its efforts toward vegetable or "salad" crops that require little or no processing, and might be suitable for small production systems on the Intl. Space Station.

Committees / Panels:

ASHS Plant Biology Working Group (Stutte)
ASHS CE Working Group (Stutte, Yorio, Sager, Wheeler)
ASAE Env. of Plant Structures Com. (Sager)
Plant Growth Regulator Society of America Steering Com. (Stutte)
National Research Council (NRC) Visiting Associate (Dixon)

Recent Papers / Chapters Published:

Bucklin, R.A., J.D. Leary, V. Rygalov, Y. Mu, and P.A. Fowler. 2001. Design parameters for Mars deployable greenhouses. SAE Technical Paper 2001-01-2428.

Colon, G. and J.C. Sager. 2001. Electrolytic removal of nitrate from crop residues. Life Support and Biosphere Science 7:291-299.

Darnell, R.L. and G.W. Stutte. 2001. Nitrate concentration effects on NO_3–N uptake and reduction, growth and fruit yields in strawberry. J. Amer. Soc. Hort. Sci. 125:560-563.

Goins, G.D., L.M. Ruffe, N.A. Cranston, N.C. Yorio, R.M. Wheeler, J.C. Sager. 2001. Salad crop production under different wavelengths of red light-emitting diodes (LEDs). SAE Tech. Paper 2001-01-2422.

Kuznetov O.A., C.S. Brown, H.G. Levine, W.C. Piastuch, M.M. Sanwo-Lewandowski, K.H. Hasenstein. 2001. Composition and physical properties of starch in microgravity-grown plants. Adv Space Res. 28(4):651-658.

Levine, L.H., A.G. Heyenga, H.G. Levine, J-W. Choi, L.B. Davin, A.D. Krikorian, N.G. Lewis. 2001. Cell-wall architecture and lignin composition of wheat developed in a µ-g environment. Phytochem. 57:835-846.

Monje, O., J. Garland, and G.W. Stutte. 2001. Factors controlling oxygen delivery in ALS hydroponic systems. SAE Technical Paper 2001-01-2425.

Monje, O., G.W. Stutte, H.T. Wang, and C.J. Kelly. 2001. NDS water pressures affect growth rate by changing leaf area, not single leaf photosynthesis. SAE Technical Paper 2001-01-2277.

Paul, A.L., C.J. Daugherty, E.A. Bihn, D.K. Chapman, K.L.L. Norwood, and R.J. Ferl. 2001. Transgene expression patterns indicate that spaceflight affects stress signal perception and transduction in *Arabidopsis*. Plant Physiology 126:613-621.

Rygalov, V.Ye., R.A. Bucklin, A.E. Drysdale, P.A. Fowler, and R.M. Wheeler. 2001. The potential for reducing the weight of a Martian greenhouse. SAE Technical Paper 2001-01-2360.

Strayer, R., V. Krumins, M. Hummerick, and C. Nash. 2001. Bioprocessing to recover crop nutrients from Advanced Life Support (ALS) solid wastes: Improving rapid biological processing of ALS inedible crop residues. SAE Technical Paper 2001-01-2208.

Strayer, R.F., M. Hummerick, V. Krumins, D. Back, and C. Ramos. 2001. Bioprocessing to recover crop nutrients from ALS Solid Wastes: A two-stage solid-liquid separation system for removal of particulates from bioreactor "broth". SAE Technical Paper 2001-01-2205.

Stryjewski, E., G. Goins, and C. Kelly. 2001. Quantitative morphological analysis of spinach leaves grown under light-emitting diodes or sulfur-microwave lamps. SAE Technical Paper 2001-01-2272.

Stutte, G.W., O.M. Monje, G.D. Goins and L.M. Ruffe. 2001. Evapotranspiration and photosynthesis characteristics of two wheat cvs. in the biomass production system. SAE Tech. Paper 2001-02-2180.

Subbarao, G.V., R.M. Wheeler, L.H. Levine, and G.W. Stutte. 2001. Glycine betaine accumulation, ionic and water relations of red-beet at contrasting levels of sodium supply. J. Plant Physiology 158:767-776.

Subbarao, G.V., L.H. Levine, R.M. Wheeler, and G.W. Stutte. 2001. Glycine betaine accumulation—Its role in stress resistance. *In*: M. Pessarakli (*ed*.), *Handbook Plant and Crop Physiol., 2nd Ed*. pp 881-907.

Subbarao, G.V., R.W. Wheeler, W. Berry, and G.W. Stutte. 2001. Sodium—A functional nutrient. *In*: M. Pessarakli (*ed.), Handbook of Plant and Crop Physiology, 2nd Ed.* pp 363-384.

Tynes, G.K., T. W. Dreschel, H.G. Levine, and H. Kasahara. 2001. An evaluation of a fibrous ion exchange resin substrate for the provision of nutrients to wheat growing on a porous tube nutrient delivery system. SAE Technical Paper 2001-01-2177.

Yorio, N.C., G.D. Goins, H.R. Kagie, R.M. Wheeler, J.C. Sager. 2001. Improving spinach, radish, and lettuce growth under red light-emitting diodes (LEDs) with blue light supplementation. HortSci. 36:380-383.

Yorio, N.C., J.E. Judkins, J.L. Garland, M.E. Hummerick, and T.H. Englert. 2001. Utilization of recovered inorganic nutrients from composted fresh or oven-dried inedible plant biomass for supporting growth of wheat in a BLSS. SAE Technical Paper 2001-02-2273.

Wheeler, R.M., G.W. Stutte, G.V. Subbarao, and N.C. Yorio. 2001. Plant growth and human life support for space travel. *In*: M. Pessarakli (*ed*.), *Handbook of Plant and Crop Physiology 2nd Ed*. pp. 925-941.

Website:

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