NCERA-101 Station Report
Sierra Space/ORBITEC, Madison WI

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1. Impact Nugget
Sierra Space continues to develop environmental control technologies for space-based biological and physical-chemical life support systems, technologies that may have applications for terrestrial environmental control systems.

2. New Facilities and Equipment
Nothing to report.

3. Unique Plant Responses
Nothing to report.

4. Accomplishment Summaries
Microgravity Plant Growth
Veggie
The Veggie units fabricated by Sierra Space were delivered to the ISS in 2014 and 2017. The 2014 unit was replaced with a new unit in 2022. These units continue to be actively used to support University and Government plant research, crop production testing, and technology demonstrations on the ISS.

Advanced Plant Habitat
Sierra Space also continues to support the Advanced Plant Habitat Unit on ISS. The APH was fabricated by Sierra Space and delivered to orbit in 2017. It is being regularly used for academic and government plant research.

XROOTS
XROOTS was designed with multiple independent growth chambers used in parallel to evaluate aeroponic and hydroponic nutrient and water delivery in microgravity. The first Technology Demonstration was completed on ISS at the end of October 2022. XROOTS demonstrated the feasibility of using aeroponic and hydroponic techniques for plant growth in microgravity (Figure 1). A reflight of XROOTS is being prepared for early 2025.

Figure 1. L>R Radish, Mizuna, and Dwarf Wheat plants grown in aeroponics system on ISS.
Water and Nutrient Delivery System with Variable Plant Spacing System

Sierra Space completed Phase A of a NASA NRA for Development of Microgravity Food Production: Plant Watering, volume management, and novel plant research on the ISS. Phase A emphasis was on variable plant spacing (Figure 2). We have received a Phase B award with an emphasis on soilless Water and Nutrient Delivery System integrated with Variable Plant Spacing, designed for eventual operation in the planned NASA KSC Ohalo plant growth facility.

Figure 2. Lettuce (cv. Outredgeous) growing in aeroponic variable plant spacing system prototype.

Aerospace Environmental Control & Life Support Systems

Sierra Space is currently “all hands on deck” _for the first flight (uncrewed) of our Dream Chaser orbital vehicle to the ISS. Dream Chaser is a winged vehicle designed for soft runway landings and is currently undergoing final testing at the NASA Armstrong Test Facility in Ohio (Figure 3).

Figure 3. Dream Chaser vehicle Tenacity, mated with its Shooting Star Cargo Module undergoing final testing at NASA Armstrong Test Facility in Ohio.

We are also currently testing Sierra Space’s_ _Large Inflatable Fabric Environment (LIFE) habitat modules (Figure 4). The LIFE habitat plans include 2-3 Astro Garden modules.

Figure 4. Sierra Space burst testing of 1/3 scale LIFE Habitat prototype. Structure conservatively met structural safety requirements.

Impact Statements

- Sierra Space is working toward development of hybrid life support systems for spaceapplications, integrating biological and physical/chemical technologies, advancing thistechnology to meet the performance and quality needs of long duration space applications.Some of this technology may be transferable to terrestrial protected agriculture systems.
- Sierra Space continues to develop LED lighting configurations and control strategies forplant, human, and vehicle lighting applications to provide increased lighting system utilityfor aerospace and gravitational biology applications.
- Sierra Space continues to use its environmental control, gravitational biology, and humanlife support work in our outreach efforts to spark interest in middle school, high school, andcollege students toward STEM fields.

5.Published Written Works

Jess M. Bunchek, Mary E. Hummerick, LaShelle E. Spencer, Matthew W. Romeyn, MillenniaYounge, Robert C. Morrow, Cary A. Mitchell, Grace L. Douglas, Raymond M. Wheeler and Gioia D. Massa. 2024. Pick-and-eat space crop production flight testing on the International Space Station. JOURNAL OF PLANT INTERACTIONS 2024, VOL. 19, NO. 1, 2292220 https://doi.org/10.1080/17429145.2023.2292220.

Morsi, A.H., G.D. Massa, R.C. Morrow, R.M. Wheeler, M. A. Elsysy, C.A. Mitchell. 2023. Leaf yield and mineral content of mizuna in response to cut-and-come-again harvest, substrate particle size, and fertilizer formulation in a simulated spaceflight environment. Life Sciences in Space Research 40 (2024) 106–114.

Sheibani F, Bourget M, Morrow RC, and Mitchell CA (2023) Close-canopy lighting, an effective energy-saving strategy for overhead sole-source LED lighting in indoor farming. Front. Plant Sci. 14:1215919. doi: 10.3389/fpls.2023.1215919.

Morrow, R.C., J. P. Wetzel, S.A. Moffett, M.R. Bair, and L. Kelsey. 2023. The Roles of Plants in a Commercial Space Habitat. 52nd International Conference on Environmental Systems. Paper ICES-2023-349.

6.Scientific and Outreach Oral Presentations

Spern, C., C. Khodadad, M. Hummerick, J. Gooden, A. Dixit, J. Wetzel, R. Morrow, O.Melendez, R. Wheeler, Y. Zhang. 2023. A molecular exploration of the XROOTS hydroponic/aeroponic system on ISS. ASGSR Annual Conference (Abstract)

Gooden, J., M. Hummerick, C. Spern, C. Khodadad, R. Morrow, J. Wetzel, O. Melendez, R. Wheeler, Y. Zhang. 2023. The microbiology of crops grown in the eXposed Root On-Orbit Test System on the International Space Station. ASGSR Annual Conference (Abstract)

7.Other relevant accomplishments, news, and activities.

Sierra Space's applications group is still focused on Propulsion and Environmental Systems (including plant payloads), and continues to operate in our facilities in Madison, Middleton, and Baraboo Wisconsin. We collaborate heavily with NASA Kennedy Space Center for our plants in space projects.

8.Website:

Sierra Space: http://www.sierraspace.com/