

## Operational Evaluation of VEGGIE Food Production System in the Habitat Demonstration Unit

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The 2010 Desert Research and Technology Studies (DRATS) of the VEGGIE Food Production System in the Habitat Demonstration Unit (HDU) Pressurized Excursion Module (PEM) was the first operational evaluation of salad crop production technology in a NASA analog test. A systematic evaluation of rooting media and nutrient delivery systems were evaluated for three lettuce cultivars that have shown promise as candidates for a surface based food production system. The VEGGIE nutrient delivery system worked well, was able to be maintained by multiple operators with a minimum of training, and supported excellent lettuce growth for the duration of the test. A Hazard Analysis and Critical Control Point (HACCP) evaluation was performed using ProSan<sup>™</sup> as sanitation agent prior to consumption was approved, and the crew was allowed to consume the lettuce grown using the VEGGIE light cap and gravity based nutrient delivery system at the completion of the 14-day DRAT field test. The DRAT field test validated the crew operations; Growth of all lettuce cultivars was excellent. The operational DRAT field testing in the HDU identified light quality issues related to morphology and pigment development that will need to be addressed through additional testing. Feedback from the crew, ground support personnel, and human factors leads was uniformly positive on the psychological value of having the crop production system in the excursion module. A number of areas have been identified for future work, to minimize the "footprint" of the Food Production system through creative use of unused wall and floor space in the unit. (Funded through NASA KSC FY10 CTC grant)

### Nomenclature

Antho	=	Anthocyanin
CEC	=	Controlled Environment Chamber
CEL	=	Controlled Environment Laboratory
CFU	=	Colony forming units
CTC	=	Core Technical Capabilities
DAP	=	Days After Planting
DM	=	Dry Mass
DRATS	=	Desert Research and Technology Studies
ESMD	=	Exploration Systems Mission Directorate

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## Concept for Sustained Plant Production on ISS Using VEGGIE Capillary Mat Rooting System

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Plant growth in microgravity presents unique challenges associated with maintaining appropriate conditions for seed germination, seedling establishment, maturation and harvest. They include maintaining appropriate soil moisture content, nutrient balance, atmospheric mixing and containment. Sustained production imposes additional challenges of harvesting, replanting, and safety. The VEGGIE is a deployable (collapsible) plant growth chamber developed as part of a NASA SBIR Phase II by ORBITEC, Madison, WI. The intent of VEGGIE is to provide a low-resource system to produce fresh vegetables for the crew on long duration missions. The VEGGIE uses a LED array for lighting, an expandable bellows for containment, and a capillary matting system for nutrient and water delivery. The project evaluated a number of approaches to achieve sustained production, and repeated plantings, using the capillary rooting system. A number of different root media, seed containment, and nutrient delivery systems were evaluated and effects on seed germination and growth were evaluated. A number of issues limiting sustained production, such as accumulation of nutrients, uniform water, elevated vapor pressure deficit, and media containment were identified. A concept using pre-planted rooting packs shown to effectively address a number of those issues and is a promising approach for future development as a planting system for microgravity conditions. (Supported by NASA IPP Grant).

### Nomenclature

BPSe	=	Biomass Production System for Education
CDDF	=	Center Director Discretionary Funds
CEC	=	Controlled Environment Chamber
CTB	=	Crew Transfer Bag
DAP	=	Days after planting
DI	=	Deionized water
DM	=	Dry Mass
EC	=	Electrical Conductivity
FM	=	Fresh Mass
IC	=	Ion chromatography
ICP	=	Inductively coupled plasma spectrometry

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# Plant Atrium System for Food Production in NASA's Deep Space Habitat Tests

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In preparation for future human exploration missions to space, NASA evaluates habitat concepts to assess integration issues, power requirements, crew operations, technology, and system performance. The concept of a Food Production System utilizes fresh foods, such as vegetables and small fruits, harvested on a continuous basis, to improve the crew's diet and quality of life. The system would need to fit conveniently into the habitat and not interfere with other components or operations. To test this concept, a plant growing "atrium" was designed to surround the lift between the lower and upper modules of the Deep Space Habitat and deployed at NASA Desert Research and Technology Studies (DRATS) test site in 2011 and at NASA Johnson Space Center in 2012. With this approach, un-utilized volume provided an area for vegetable growth. For the 2011 test, mizuna, lettuce, basil, radish and sweetpotato plants were grown in trays using commercially available red / blue LED light fixtures. Seedlings were transplanted into the atrium and cared for by the crew. Plants were then harvested two weeks later following completion of the test. In 2012, mizuna, lettuce, and radish plants were grown similarly but under flat panel banks of white LEDs. In 2012, the crew went through plant harvesting, including sanitizing the leafy greens and radishes, which were then consumed. Each test demonstrated successful production of vegetables within a functional hab module. The round red / blue LEDs for the 2011 test lighting cast a purple light in the hab, and were less uniformly distributed over the plant trays. The white LED panels provided broad spectrum light with more uniform distribution. Post-test questionnaires showed that the crew enjoyed tending and consuming the plants and that the white LED light in 2012 provided welcome extra light for the main hab area.

## Nomenclature

<i>AES</i>	=	Advanced Exploration Systems
<i>DRATS</i>	=	Desert Research and Technology Studies
<i>DSH</i>	=	Deep Space Habitat
<i>ECLSS</i>	=	Environment Control and Life Support System
<i>HDU</i>	=	Habitat Demonstration Unit
<i>JSC</i>	=	Lyndon B. Johnson Space Center
<i>KSC</i>	=	John F. Kennedy Space Center
<i>LED</i>	=	Light Emitting Diode

## I. Introduction

LONG duration space outposts will rely on imported, preserved foods to sustain the crew. Growing fresh salad crops and herbs could improve the acceptability and variety of a stored diet and provide a consistent supply of

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