Space Plant Biology Research at KSC

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Introduction

The Exploration Research and Technology Programs directorate (UB) is responsible for management of the ISS, to include processing payloads and supporting scientific experiments conducted on the ISS. UB also manages research and technology programs at KSC, to include Advanced Exploration Services (AES) and Space Life and Physical Sciences (SLPS). UB-A is the ISS Utilization and Life Sciences Division and is primarily focused on conducting and supporting biological research, mostly rodent and plant, on the ISS.

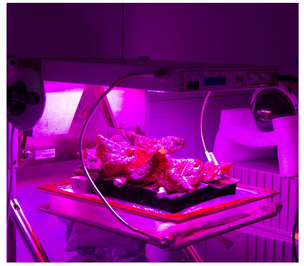
Space Farming

Long duration space exploration will require the capability for crews to grow their own food. Growing food is desirable from a mass-efficiency standpoint, as it is currently not feasible to carry enough prepackaged food on spacecraft to sustain crews for long duration missions. Nutritionally, fresh produce provides key nutrients that are not preserved well in pre-packaged meals (e.g. vitamins C and K) and those that are able to counteract detrimental effects of space flight, such as antioxidants to combat radiation exposure and lutein for decreasing macular degeneration. Additionally, there are significant psychological benefits of maintaining gardens, one being an indicator for the passage of time.

Space farming is the foundation for bioregenerative life support systems, closed ecological systems that are able to provide services such as conversion of CO_2 to O_2, treatment of gray water, and recovery and recycling of nutrients from inedible plant material and human waste.

Veggie

Veggie is a vegetable production unit located in the Columbus module of the ISS. It uses LEDs for lighting and currently utilizes a passive watering system to deliver water to 'plant pillows' that arrive on station preloaded with media, time release fertilizer, and seeds. Veggie is open to the cabin and does not have any environmental controls beyond light and fan intensity.



Veg-01 *March 2014-March 2016*

- Two trials of 'Outredgeous' red romaine lettuce
- The second trial, completed in August 2015, was consumed by the astronauts on orbit (A first for NASA*).
- Zinnias grown as a precursor to tomatoes, 90 day long growth cycle. The crew (and science team) experienced a variety of challenges, to include overwatering, desiccation, and fungal invasion. In December 2015, Scott Kelly assumed autonomous control of watering plants. Harvested on Valentine's Day 2016.
- Recovered seeds from the flight zinnias in June 2016, currently conducting germination studies.

Veg-03 *Launched April 2016*

- Prepared two sets of 'Tokyo Bekana' Chinese cabbage and one set of 'Outredgeous' red romaine plant pillows that were sent to station on SpaceX-08.
- Red romaine trial will begin late summer/early fall.
- Interested in experimenting with autonomous astronaut gardening for daily care of plants.
- Testing 'cut and come again' as a way to provide consistent supply of produce and maximize per plant yield.

HRP ILSRA: Pick n' Eat

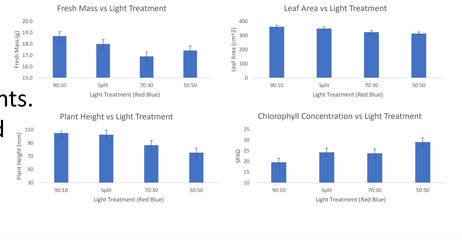
Objective of study is to develop two new crops, 'Tokyo Bekana' Chinese cabbage and 'Red Robin' dwarf tomato for growth on Veg-04 and Veg-05 flight missions. Emphasis on advancing understanding of how plants respond to growing under LEDs, a method of lighting that is relatively new to controlled agriculture.

- Four different light treatments with varying ratios of Red: Blue light
- Three different time release fertilizer treatments; how will light affect rates of nutrient uptake?
- Performing nutrient analysis to determine what combination of light and fertilizer produces the most nutrient-laden plants.

Preliminary Light Trt. Results

Figure 1. Chinese cabbage growth results by light treatment

Plants grown under treatments with higher ratios of red light grew largest, with the opposite being true for blue light treatments. Plants grown under blue light had significantly higher chlorophyll concentrations than those under red light.



Current & Future ILSRA Work

- Investigating LED induced anomalies in Chinese cabbage.
- Microbial analysis of Chinese cabbage for food safety certification.
- First trial of dwarf tomatoes planted in late June 2016, harvest in September 2016.