

Introduction to Food Production Challenges in Space

Food is one of the most critical elements required for human survival. Though the time to effect may be shorter for oxygen, shelter, or water, the consequences are just as serious. Stored food has also been shown by studies performed by NASA's Evolvable Mars Campaign team to be a significant, multi-ton logistics burden for initial human exploration missions to Mars. Popular fiction and media assumes that in-situ production of food from plants will be part of future space missions. Scientific experiments have demonstrated that plant growth in space is feasible. Crew response to food and their time spent tending the plants also provide evidence for the benefit that plants can have for future missions. However, illustrations of possible options do not prove that biological systems will be cost effective or reliable. On Earth, biological systems are considered robust because they can recover with time, but success conditions for a space mission requires the safe return of the same crewmembers who began the mission, not just recovery of survivable conditions for another group of human beings.

Agriculture in space is still in the relatively early stages of scientific discovery, and while it may have immediate benefits to human space missions even in these initial phases, important challenges still exist. Mission planners will not accept plants into the spacecraft system as an enabling, mass saving component, until the open questions have been solved and reliability and predictability has been demonstrated. The questions are also often interrelated, and a recent multidisciplinary team within NASA attempted to identify key enabling questions so that they could be addressed in future research. These challenges can be parsed into key human research questions, physical science questions, biological science questions, technology development issues, and system integration questions. Human research must provide evidence of what nutrients will provide most benefit to the crew, and of the psychological benefits that plants or food will have as compared to any other possible countermeasures. Physical science needs to provide key information on water and gas management for the plants and environmental control systems. Critical biological science questions exist for the plants themselves, as well as the microbiology of the plants root zone, or any organisms that could pose a threat to the plants or the human crewmembers, and understand how plants are. Technology developers must identify the elements that can make plant growth system cost effective, and prove the elements are robust. And system integrators must understand and be able to predict how all of the elements work together as part of the spacecraft and how they will impact all aspects of the mission.

Human beings own biology and psychology drive the complexity for the system requirements to support our life and health. We exist as an integrated system with plants and animals on Earth, even if we are sometimes physically removed from the agricultural production of own food. Understanding these challenges is critical for sustainable human existence beyond Earth, and also has the potential to provide insight and benefit to human life on Earth.