IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Biology in Space (8)

Author: Mr. Theodore Tagami
Magnitude.io, United States

Mr. Gilbert Cauthorn
Department of Space Studies, University of North Dakota, Japan
Dr. Richard Barker
University of Wisconsin, United States
Prof. D. Marshall Porterfield
Purdue University, United States
Dr. Christoph Lahtz
Space Tango, United States

COMPUTER VISION ENABLED ANALYSIS OF MEDICAGO TRUNCATULA IN MICROGRAVITY AND CLASSROOMS AROUND THE WORLD (EXOLAB 11 ON THE ISS)

Abstract

Ensuring sustainable crop production in space is a critical step toward enabling long-duration space missions and extraterrestrial settlements. The ExoLab 11 mission, an ongoing collaborative effort between academia, industry, and K-12 education around the world, is actively investigating the growth and physiological responses of *Medicago truncatula* aboard the International Space Station (ISS). As a model legume, *M. truncatula* provides beneficial insights into plant-microgravity interactions, including root architecture, phototropism, gravitropism, and stress responses. By analyzing plant responses in microgravity, this research enhances our understanding of plant integration within Biological Life Support Systems (BLSS), supporting future space habitat sustainability.

The mission launched in cold stowage on 5 November 2024 aboard SpaceX-31 cargo resupply and operated nominally for 26.5 days. The experiment returned to Earth in cold stowage on 17 December 2024. Currently, bioimaging and molecular analysis are underway to assess the morphological and genetic adaptations of *M. truncatula* in microgravity. Novel bioimaging protocols are being employed to quantify plant development in the microgravity environment. This method uses g ratio metric spectral data to identify changes that are indicative of changes in photosynthetic efficiency, activation of stress response pathways, and signal long term metabolic adaptation to the space environment. Post-flight analysis leverages a suite of microscopy techniques to conduct a detailed assessment of vascular integrity, plastid distribution, and cellular architecture under spaceflight conditions. These high-resolution images will be integrated into NASA's GeneLab repository, enriching the dataset for optimizing space crop cultivation strategies and advancing bioregenerative life support research by providing these data for machine learning.

Beyond scientific outcomes, ExoLab 11 is actively engaging thousands of students and more than 100 educators across 8 countries through an online platform, where parallel Earth-based experiments are being conducted. Participating classrooms are monitoring *M. truncatula* growth in real-time and analyzing experimental results alongside ISS data, fostering the next generation of space biologists and engineers.

This presentation will provide a status update on the mission's ongoing analysis, highlighting preliminary findings, imaging data, and associated challenges. The insights gained from ExoLab 11 will help refine sustainable agricultural methods for lunar and Martian habitats, reinforcing NASA's goals for resilient, autonomous food production systems in space.