Evaluating Plant Growth in CubeSat Centrifuge Terrariums to Simulate Lunar Surface Conditions

Farah Alqaraghuli, Claire Pedersen, Jekan Thangavelautham

Space and Terrestrial Robotics and Exploration Laboratory, The University of Arizona, Tucson, Arizona, 85705, United States

Establishing sustainable habitats on off-world bodies such as the Moon is critical for enabling the survival of astronauts for long term space missions. Central to this idea is the cultivation of plants on the lunar surface, serving a diverse range of purposes such as food production, carbon dioxide removal, and the overall enhancement of astronaut well-being to extend mission duration. Here, a concept is proposed to replicate lunar conditions in a centrifuge, growing various plant species to further examine the ability of plants to withstand space conditions. The proposed concept will be conducted inside a 4U terrarium that will be housed inside a 6U CubeSat in low Earth orbit (LEO). Each species of plant housed inside the terrarium will be subjected to conditions mirroring the lunar climate including similar microgravity, radiation exposure, sunlight access, temperature variations, humidity levels, and vacuum conditions. Each experiment will last a total of 28 Earth days, which is equivalent to one lunar day with alternating periods of daytime and nighttime simulating the variations in access to sunlight on the Moon. Temperatures ranging from 120 to -150 ℃ will be implemented to mimic day and night temperature fluctuations on the moon. Three plant species were chosen to undergo this experiment based on their resilience to survive harsh space conditions, their representation of a diverse range of species that will aid in the evaluation of the ability of plants to adapt to space conditions, and their relevance in addressing the various needs of astronauts in missions. Arabidopsis plants are small flowering plants with rapid growth rates and were selected because they are model organisms in plant biology and genetic studies making them ideal candidates for studying the life cycle of plants in space. Alfalfa seeds were chosen for their high nutritional value to astronauts, their resilience and ability to a wide range of environmental conditions, and their nitrogen fixing root system which presents an opportunity to be tested with lunar regolith. Douglas fir trees were chosen for their carbon sequestration and biomass production capabilities, hence making them suitable for constructing lunar structures and CO_2 scrubbing if grown properly. This experiment will serve as a proof of concept for the beginning of cultivating life in extraterrestrial environments and will therefore present the possibility of extending mission duration and improving the quality of life for astronauts.