Fiscal Year:	FY 2024	**Task Last Updated:**	FY 11/01/2023
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Project Title:	Determining the Impact of Space Radiation and Simulated Microgravity on Plant Root Microbial Community Composition and Function		
Division Name:	Space Biology		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	None		
Human Research Program Risks:	None		
Space Biology Element:	(1) Microbiology (2) Plant Biology		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	(1) Bioregenerative Life Support		
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Zip Code:	53226-3548	**Congressional District:**	5
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2021 Space Biology NNH21ZDA001N-SBPS E.9: Plant Studies
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No. of Post Docs:	1	**No. of PhD Degrees:**	0
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No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA KSC
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:	There are no changes to the PI and CoIs.		
COI Name (Institution):	Gilroy, Simon Ph.D. (University of Wisconsin, Madison) Ané, Jean-Michel Ph.D. (University of Wisconsin, Madison)		
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Task Description:	The proposed research will increase NASA's understanding of how living systems respond to environments encountered during missions beyond low-Earth orbit. While plant studies are relevant to fundamental science interests within Space Biology, the psychological and nutritional benefits of growing plants in deep space make this research valuable to the Human Research Program. All living organisms will be constantly exposed to ionizing radiation from galactic cosmic rays and intermittent exposure to solar particle events during deep space missions. Our objective is to address the likelihood of a new, potentially showstopping effect of space radiation that could have significant impact on using plants as bioregenerative life support for extended human spaceflight, i.e., the disruption of plant root microbial community structure and function. While the biological effects of charged particle radiations on mammalian systems are actively being explored, their impact on the ecological niche of plants is poorly understood. This could have substantial ramifications for crew health and psychology. A visionary concept is proposed where space radiation will result in shifts in the diversity of the microbial community within the rhizosphere, preventing normal microbial function, and potentially promoting the proliferation of pathogenic soil microbiota. This concept is unexplored. Should space radiation decrease the diversity of the soil rhizosphere microbiome and microbial function, this could be a significant obstacle limiting our ability to deliver an adequate supply of food to astronauts. The studies proposed could impact extended missions; the total dose of radiation absorbed by a living organism for a Mars mission would be ~ 0.75 Sv. Total mission dose equivalent for the soil rhizosphere microbiome would be comparable. However, the impact of galactic cosmic rays on the health of the rhizosphere microbiome is unknown. Studies proposed in this application break new ground and address an unmet mission need by determining the impact of space radiation on plant root microbial community diversity and its effect on crop growth and nutritional value. We will use a ground-based plant model approach using a spectrum of high-energy charged particle beams produced at the NASA Space Radiation Laboratory that simulates exposure to a mission-relevant dose of galactic cosmic rays. We will explore a likely significant combinatorial effect of the multiple stressors inherent in spaceflight by determining the impact of radiation and simulated microgravity on the plant and its root microbial community composition and function. We will use the 1-d clinostat as our principal ground-based microgravity analog. The central hypothesis of this project is that space radiation disrupts plant root microbial community composition resulting in impaired microbial function. Aim 1. Determine dose-rate effects of exposure to space radiation on plant root microbial community composition and microbial function. Arabidopsis thaliana plants inoculated with a well-characterized publicly available synthetic community of 188 bacteria, representing taxonomic and functional diversity from A. thaliana roots and soil in the natural environment, will be irradiated with a single fraction or multiple fractions of simulated galactic cosmic rays given over 1 day or 30 days resulting in a cumulative dose of 0.75 Gy. Aim 2. Determine the combined effects of space radiation and simulated microgravity on microbiota community composition. A. thaliana will be irradiated with a single fraction exposure to 0.75 Gy of space radiation with and without simulated microgravity. Responses will be analyzed as described in Aim 1. We have assembled a strong team comprising scientists with complementary experience in ground-based studies of space radiation on rats (Baker), plant-microbiome interactions (Ané), and spaceflight and clinostat-based analyses (Gilroy).
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This proposed research will increase NASA's understanding of how living systems respond to unique environments during missions beyond low earth orbit (LEO). All living organisms from the crew and the microbes that will inevitably accompany them on voyages will be constantly exposed to ionizing radiation from galactic cosmic rays in deep space. Plants are integral to these missions, providing a core component of bioregenerative life support: replenishing the atmosphere, providing nutrition, and purifying water in the spaceflight environment, just as on Earth. However, on Earth, plants grow in the context of the microbiota they interact with. Some of these microbes are pathogenic. However, a large proportion benefits the plant by mobilizing or providing nutrients, stimulating plant growth, or warding off pathogens. Thus, the plant's microbiome, especially that found around the roots, can significantly impact plant health and usable crop yields. Understanding how the microbiome in plant roots is affected by gravity and radiation affect will provide insight into how crop growth in stressful environments can be improved on the Earth.
Task Progress:	Space radiation and microgravity pose two major health risks during and after the conduct of deep space exploratory missions. Humans and plants have evolved with minimal exposure to galactic cosmic radiation (GCR) and the constant downward force of gravity. Long duration exploratory missions to the Earth’s Moon and the planet Mars are actively being planned. During these missions, plants and astronauts will not be protected from GCR conferred by the Earth’s magnetosphere and the force of gravity will decrease as distance increases from the surface of the Earth. The extent that plant health will be adversely affected by these spaceflight stressors is a major unknown and a concern to NASA. A clear understanding of how plants and microbes interact in spaceflight, the changes over time, and whether preemptively providing a defined microbiome would be beneficial remains a critical gap in our knowledge. A visionary concept is proposed where space radiation will likely result in shifts in the diversity of the microbial community within the rhizosphere, preventing normal microbial function and potentially promoting the proliferation of pathogenic soil microbiota. This concept is unexplored. Should space radiation decrease the diversity of the soil rhizosphere microbiome and microbial function, this could be a significant obstacle limiting our ability to deliver adequate food supplies from bioregenerative systems to astronauts. The central hypothesis of this project is that simulated microgravity interacts with whole-plant exposure to space radiation to potentiate the risk for plant root microbial community disruption, resulting in impaired interactions with the host plant. Two specific aims are proposed to directly address issues of rhizosphere microbial community dysbiosis using experimental approaches in a plant model relevant to the research questions. The proposed investigations directly address essential aspects of the NASA Space Biology and Human Research Programs. The research directly relates to recommendations P1-3 in the 2011 Decadal Survey on NASA's basic research on the life and physical sciences from the National Academies, targeting plant and microbial responses to spaceflight stressors and how these affect the

	interactions between these organisms. This work also addresses Degenerative Tissue Gaps, as outlined in the Human Research Roadmap (FN-103, FN-203, FN-401, FN-501) and goals from the Space Biology Plan 2016-2025 (MB-1,2,3, MB-7, Plant Biology Guiding Questions 2 and 4). The proposed research will provide vital information to help close these gaps. --------- In the first year of the grant we have obtained a synthetic community of 188 bacteria from Arabidopsis thaliana and are establishing and validating a self-sustainable colony for use in our studies. Plants will be exposed to GCR in 2024.
Bibliography Type:	Description: (Last Updated: 01/29/2024)