

Fiscal Year:	FY 2022	Task Last Updated:	FY 11/08/2023
PI Name:	Poulet, Lucie Ph.D.		
Project Title:	Modeling Plant Growth and Gas Exchanges in Various Ventilation and Gravity Levels		
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) Plant Biology		
Space Biology Cross-Element Discipline:	(1) Developmental Biology		
Space Biology Special Category:	None		
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PI Organization Type:	NASA CENTER	Phone:	321-861-0713
Organization Name:	NASA Kennedy Space Center		
PI Address 1:	NASA Postdoctoral Fellow		
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PI Web Page:			
City:	Kennedy Space Center	State:	AK
Zip Code:	32899	Congressional District:	8
Comments:			
Project Type:	GROUND	Solicitation / Funding Source:	NASA Postdoctoral Program
Start Date:	01/31/2019	End Date:	01/31/2022
No. of Post Docs:	1	No. of PhD Degrees:	
No. of PhD Candidates:		No. of Master' Degrees:	
No. of Master's Candidates:		No. of Bachelor's Degrees:	
No. of Bachelor's Candidates:		Monitoring Center:	NASA KSC
Contact Monitor:	Administration, USRA	Contact Phone:	
Contact Email:	npphelp@usra.edu		
Flight Program:			
Flight Assignment:	NOTE: End date changed to 01/31/2022 per NASA-KSC; original date was 01/31/2021. (Ed. 12/01/21)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Massa, Gioia Ph.D. (MENTOR/ NASA Kennedy Space Center)		
Grant/Contract No.:	NASA Postdoctoral Program		
Performance Goal No.:			
Performance Goal Text:			
Task Description:	<p>NASA Postdoctoral Program Fellow</p> <p>Human exploration of the deep solar system will necessitate plant growth for food production, which requires understanding plant growth in various gravity levels. The objectives of this project are predicting biomass production in different ventilation settings and defining the lowest adequate ventilation for optimal plant growth, by performing local studies of leaf gas exchanges. It will expand on results obtained in the past in parabolic flight and International Space Station (ISS) experiments, which have shown the effects of low ventilation and low gravity on gas exchanges at the leaf surface and photosynthesis. The methodology combines the development and validation of a mechanistic model of plant growth, computational fluid dynamics simulations, and experiments in different time frames. Expected results are to obtain a physically and biologically structured model of plant growth in reduced gravity environments, at least validated in Earth's conditions.</p>		

Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	
Task Progress:	<p>Progress compiled from final report delivered to NASA (Ed., 11/8/23): GAS EXCHANGE MEASUREMENTS</p> <p>The main project of my NASA Postdoctoral Program (NPP) appointment was to further develop a plant gas exchange model in a reduced gravity environment using data collected under different airflow in 1g. This involved designing and building a custom-made measurement chamber that is attached to the LI-COR 6800 infra-red gas analyzer and allows real-time measurement of plant photosynthesis and transpiration. The development of this chamber took time; the tests began at the beginning of the pandemic and abruptly stopped for 6 months. I resumed them in the last quarter of 2020 but had two instrument failures in January 2021 and August 2021, which resulted in one- to two-month delays each time. Data collection was completed in December 2021.</p> <p>PARABOLIC FLIGHT CAMPAIGNS</p> <p>Our interest in measuring gas exchange of microgreen canopies led to the development of small 10 cm x 10 cm microgreen growth units that enable the separation between the root zone and the aerial part of the plants. We recognized that this hardware concept could ease harvesting microgreens in microgravity and on Earth, so we applied for a NASA Kennedy Space Center (KSC) Innovation Research and Technology Development (IR&TD) grant to develop this concept further and test it in one parabolic flight. We received funding for this project in March 2021 and applied for two more flights with the internal NASA Flight Opportunity program, which were awarded in July 2021. I was the science PI for this project and was engaged in the payload development process with ZeroG from start to finish, as well as managing the team, paperwork, and logistics for the flights.</p> <p>From March 2021 to January 2022, our team developed multiple harvesting and bagging methods for microgreens that we tested during two parabolic flight campaigns that occurred in November and December 2021.</p> <p>ADVANCED PLANT HABITAT ISS EXPERIMENT</p> <p>In July 2021, the PH-04 experiment was initiated aboard the International Space Station (ISS) in order to grow chile peppers in space - the first fruits to grow in low-Earth orbit and the longest plant experiment in space. Along with this objective, we were able to collect photosynthesis measurements on the plants, towards the end of the experiment in November 2021. I was involved in the design of an experimental protocol for photosynthesis measurements with different airflows. We are still in the process of analyzing these data and are planning to publish them.</p>
	<p>Bibliography Type: Description: (Last Updated: 11/09/2023)</p>
	<p>Articles in Peer-reviewed Journals</p> <p>Poulet L, Engeling K, Hatch T, Stahl-Rommel S, Velez Justiniano Y-A, Castro-Wallace S, Buncek J, Monje O, Hummerick M, Khodadad CLM, Spencer LE, Pechous J, Johnson CM, Fritsche R, Massa GD, Romeyn MW, O'Rourke AE, Wheeler RW. "Large-scale crop production for the Moon and Mars: Current gaps and future perspectives." Front Astron Space Sci. 2022 Feb 4;8:733944. https://doi.org/10.3389/fspas.2021.733944, Feb-2022</p>
	<p>Articles in Peer-reviewed Journals</p> <p>Poulet L, Zeidler C, Buncek J, Zabel P, Vrakking V, Schubert D, Massa G, Wheeler R. "Crew time in a space greenhouse using data from analog missions and Veggie." Life Sci Space Res (Amst). 2021 Nov;31:101-12. Epub 2021 Sep 4. https://doi.org/10.1016/j.lssr.2021.08.002; PMID: 34689942, Nov-2021</p>
	<p>Articles in Peer-reviewed Journals</p> <p>Boles HO, Poulet L, Johnson CM, Torres JJ, Koss LL, Spencer LE, Massa GD. "Design, build, and testing of hardware to safely harvest microgreens in microgravity." Gravit Space Res. 2023 Oct 30;11(1):1-14. https://doi.org/10.2478/gsr-2023-0001, Oct-2023</p>
	<p>Articles in Peer-reviewed Journals</p> <p>Johnson CM, Boles HO, Spencer LE, Poulet L, Romeyn M, Buncek JM, Fritsche R, Massa GD, O'Rourke A, Wheeler RM. "Supplemental food production with plants: A review of NASA research." Front Astron Space Sci. 2021 Nov 10;8:734343. Mini review. https://doi.org/10.3389/fspas.2021.734343, Nov-2021</p>
	<p>Articles in Peer-reviewed Journals</p> <p>Poulet L, Dalmas B, Goncalves B, Noûs, C, Vernay A. "As researchers, we need to engage more into public outreach towards children in the future." J Futures Stud. 2021;26(1):75-82. https://doi.org/10.6531/JFS.202109_26(1).0006, Sep-2021</p>
	<p>Articles in Peer-reviewed Journals</p> <p>Heinicke C, Adeli S, Baque M, Correale G, Fateri M, Jaret S, Kopacz N, Ormo J, Poulet L, Verseux C. "Equipping an extraterrestrial laboratory: Overview of open research questions and recommended instrumentation for the Moon." Adv Space Res. 2021;68:2565-99. https://doi.org/10.1016/j.asr.2021.04.047, Jan-2021</p>
	<p>Articles in Peer-reviewed Journals</p> <p>Heinicke C, Poulet L, Dunn J, Meier A. "Crew self-organization and group-living habits during three autonomous, long-duration Mars analog missions." Acta Astronaut. 2021 May;182:160-78. https://doi.org/10.1016/j.actaastro.2021.01.049, May-2021</p>
	<p>Articles in Peer-reviewed Journals</p> <p>Poulet L, Dussap C-G, Fontaine J-P. "Development of a mechanistic model of leaf surface gas exchange coupling mass and energy balances for life-support systems applications." Acta Astronaut. 2020 Oct;175:517-30. https://doi.org/10.1016/j.actaastro.2020.03.048, Oct-2020</p>
	<p>Papers from Meeting Proceedings</p> <p>Poulet L, Vernay A, Goncalves B, Dalmas B, Vernay M. "A multidisciplinary scientific outreach journal designed for and made by middle and high school students to bring research closer to the classroom." 50th International Conference on Environmental Systems, June 22, 2020 (canceled). Collections. 50th International Conference on Environmental Systems, June 22, 2020 (canceled). ICES paper ICES-2020-78. https://ttu-ir.tdl.org/items/259feda0-cad5-40f5-9727-1215d4a829b6, Jun-2020</p>

Papers from Meeting Proceedings

Poulet L, Gildersleeve MK, Koss LL, Massa GD, Wheeler RM. "Development of a photosynthesis measurement chamber under different airspeeds for applications in future space crop-production facilities." 50th International Conference on Environmental Systems, June 22, 2020 (canceled). ICES paper ICES-2020-77. <https://ttu-ir.tdl.org/items/3fecda6a-65c8-4e22-8689-0ff4f65c992e>, Jun-2020