

Fiscal Year:	FY 2024	Task Last Updated: FY 01/03/2024	
PI Name:	Jinkerson, Robert Ph.D.		
Project Title:	Evaluation of Small Plants for Agriculture in Confined Environments (SPACE) Tomatoes for Space Flight Applications		
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:	None		
Space Biology Special Category:	(1) Bioregenerative Life Support		
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Comments:			
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Flight Program:	ISS		
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Orozco-Cardenas, Martha Ph.D. (University of California, Riverside)		
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	<p>Plants can have a tremendously beneficial impact on long spaceflights if some biological hurdles can be overcome. Plants on extended space expeditions can provide a fresh source of food and nutrients, CO₂ uptake capacity, and behavioral health benefits to crewmembers. Most fruit and vegetable bearing plants, however, are too large and produce too much inedible biomass to be part of a bioregenerative life support system. We have recently increased the developmental rate and harvest index of tomato plants dramatically through genetic engineering. These plants rapidly progress through their developmental cycle to produce fruit, minimizing their size and producing little non-fruit biomass. We are calling this extremely dwarf phenotype Small Plants for Agriculture in Confined Environments (SPACE) tomatoes. These plants have been evaluated on Earth but it is not known how this dwarf plant phenotype will manifest in a microgravity environment.</p> <p>This project aims to (1) cultivate SPACE tomato plants in the Advanced Plant Habitat aboard the International Space Station (ISS); (2) determine the physiological response of these plants to grow in microgravity; (3) evaluate fruit grown on the ISS for yield, nutrient levels, and microbial loading; and (4) complete a full life cycle of the SPACE tomatoes aboard the ISS and determine if growing tomatoes seed-to-seed in space alters fruit yields of progeny.</p> <p>The SPACE phenotype is innovative and potentially transformative for spaceflight and ground-based controlled environment agriculture. The SPACE tomato is uniquely suited for environments where physical space is limited. Relatively little research has been done on producing plant traits such as SPACE tomatoes because they serve little agricultural importance in present-day ground-based agricultural systems. Most other mutations that produce plant dwarfs largely keep the proportion of leafy, un-edible material to edible fruit the same. NASA has investigated several dwarf tomatoes but none have been as extreme as the SPACE tomato. The SPACE trait forces the plant quickly through its developmental cycles to produce fruit without the necessity to develop the whole plant. This results in profoundly small plants that produce fruit that is a high fraction of their biomass. This work will determine how well suited SPACE tomatoes are for a bioregenerative life support system. Morphological data of SPACE tomato plants grown in microgravity will also inform future plant genetic engineering strategies on how to create other dwarf plant varieties that are ideally suited for growth on a spacecraft in microgravity.</p>
Task Description:	
Rationale for HRP Directed Research:	<p>The SPACE phenotype is innovative and potentially transformative for spaceflight and ground-based controlled environment agriculture. The SPACE tomato is uniquely suited for environments where physical space is limited. Relatively little research has been done on producing plant traits such as SPACE tomatoes because they serve little agricultural importance in present-day ground-based agricultural systems. Most other mutations that produce dwarf plants largely keep the proportion of leafy, un-edible material to edible fruit the same. NASA has investigated several dwarf tomatoes but none have been as extreme as the SPACE tomato. The SPACE trait forces the plant quickly through its developmental cycles to produce fruit without the necessity to develop the whole plant. This results in profoundly small plants that produce fruit that is a high fraction of their biomass. This work will determine how well suited SPACE tomatoes are for a bioregenerative life support system. Morphological data of SPACE tomato plants grown in microgravity will also inform future plant genetic engineering strategies on how to create other dwarf plant varieties that are ideally suited for growth in physically confined locations, such as on Earth, in controlled environment agriculture. Data collected on SPACE tomato plant growth, yield, and performance during this project can be used to estimate similar metrics for on-Earth production of SPACE tomatoes in controlled environment agriculture setups. Additionally, optimized culture conditions for SPACE tomato plant growth, such as light, temperature, humidity, and fertilizer levels, can all be used as starting points for tomato growth in on-Earth controlled environment agriculture, such as in vertical farms.</p>
Research Impact/Earth Benefits:	
Task Progress:	<p>Plants can have a tremendous beneficial impact on long space flights if some biological hurdles can be overcome. Plants on extended space expeditions can provide a fresh source of food and nutrients, CO₂ uptake capacity, and behavioral health benefits to crewmembers. Most fruit and vegetable bearing plants, however, are too large and produce too much inedible biomass to be part of a bioregenerative life support system. We have recently increased the developmental rate and harvest index of tomato plants dramatically through genetic engineering. These plants rapidly progress through their developmental cycle to produce fruit, minimizing their size and producing little non-fruit biomass. We are calling this extremely dwarf phenotype Small Plants for Agriculture in Confined Environments (SPACE) tomatoes. These plants have been evaluated on Earth but it is not known how this dwarf plant phenotype will manifest in a microgravity environment.</p> <p>This work will determine how well-suited SPACE tomatoes are for a bioregenerative life support system. Morphological data of SPACE tomato plants grown in microgravity will also inform future plant genetic engineering strategies on how to create other dwarf plant varieties that are ideally suited for growth on a spacecraft in microgravity.</p> <p>This project aims to (1) cultivate SPACE tomato plants in the Advanced Plant Habitat (APH) aboard the International Space Station (ISS), (2) determine the physiological response of these plants to growth in microgravity, (3) evaluate fruit grown on the ISS for yield, nutrient levels, and microbial loading, and (4) complete a full life cycle of the SPACE tomatoes aboard the ISS and determine if growing tomatoes seed-to-seed in space alters fruit yields of progeny.</p> <p>In the past year, we have completed an Experiment Requirements Document (ERD). This document outlines the specific requirements and guidelines for our experiment. The ERD includes details such as the objectives of the experiment, necessary equipment, safety protocols, and procedures. Additionally, we have shown that freezing tomato fruit is not a viable approach for saving seeds for growth on the ground. Finally, late in 2023, the first set of SPACE tomatoes were starting to be grown at NASA Kennedy Space Center (KSC) in their APH analog setup.</p>
Bibliography Type:	Description: (Last Updated: 07/05/2023)