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| **Fiscal Year:** | FY 2022 | **Task Last Updated:** | FY 12/16/2021 |
| **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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| **City:** | Riverside | **State:** | CA |
| **Zip Code:** | 92507 | **Congressional District:** | 41 |
| **Comments:** | | | |
| **Project Type:** | FLIGHT | **Solicitation / Funding Source:** | 2018 Space Biology (ROSBio) NNH18ZTT001N-FG2. App D: Flight and Ground Space Biology Research |
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| **No. of PhD Candidates:** | 1 | **No. of Master' Degrees:** | |
| **No. of Master's Candidates:** | | **No. of Bachelor's Degrees:** | |
| **No. of Bachelor's Candidates:** | 1 | **Monitoring Center:** | NASA KSC |
| **Contact Monitor:** | Massa, Gioia | **Contact Phone:** | 321-861-2938 |
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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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**Task Description:**

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, $CO_2$ 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.

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.

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.

**Rationale for HRP Directed Research:**

**Research Impact/Earth Benefits:**

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**Task Progress:**

Plants can have a tremendous 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, $CO_2$ 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.

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.

This project aims to (1) cultivate SPACE tomato plants in the Advanced Plant Habitat (APH) aboard the 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.

As a first step to cultivating SPACE tomato plants in the APH aboard the ISS, we must determine optimal environmental variables and develop protocols that can be used. To achieve this, we have conducted experiments on seed sterilization, seed germination, plant growth in arcillite, and fertilizer optimization. A seed sterilization protocol was developed that can properly sterilize our seeds to prevent unwanted microbes from making it to the ISS while making sure that our seeds remain viable. Additionally, we have shown that our seeds remain viable during storage in the APH growth substrate for greater than 3 months, which will allow flexibility in scheduling the experiment. The primary growth substrate in the APH is arcillite, which is a substrate we have not previously grown our tomatoes in. We have developed methods to assess and optimize water and nutrient levels in this substrate. To provide our plants fertilizer, we are using slow release fertilizer and have identified what level of fertilizer is toxic to the plants. To determine the layout of plants in the APH, a competition experiment was planned to determine if wildtype tomato plants can outcompete SPACE tomato plants for light, water, or nutrients. A seed harvesting and replanting protocol is also in development that will work aboard the ISS in microgravity. These findings and established protocols will allow for the best chances of success when our experiment is conducted on the ISS.

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| **Bibliography Type:** | Description: (Last Updated: 07/05/2023) |