

# Project HOME: Hydroponic Operations for Mars Exploration

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## Abstract

Agriculture in enclosed structures on Mars enables astronauts to conduct extended surface exploration missions. We will evaluate multiple hydroponics systems to grow Moringa, Goji Berries, Kale, Chia, Hemp, Sweet Potatoes, and Bamboo. When these foods are combined, they contain a complete necessary set of amino acids, vitamins, minerals, fiber, carbohydrates, and nutrients for a balanced diet. The greenhouse will be powered solely through solar panels, and the plants will receive the same solar irradiance as the surface of Mars. The light intensity in the greenhouse will be kept at approximately 590 W/m<sup>2</sup> by using a shade cloth to limit the natural light from the sun. This simulates an ambient light collection and reflection system on Mars, illuminating an insulated outdoor system for agriculture. The utilization of a hydroponics system allows for a more effective method of growing superfoods in abstract environments.

## Preliminary Results

M. Oleifera was tested in a hydroponic system under Mars ambient lighting conditions of 590 W/m<sup>2</sup> for a full year. The plant tolerated repeated stem cutting (n=20), with rapid regrowth. A dry leaf yield of 0.224 g/day per plant was observed. This yield and the significant nutrient content of M. Oleifera are of interest, representing the production of significant food value shown in the table below, per the USDA reference data for M. Oleifera's nutritional content.

Nutrient	Amount Humans Require Per Day	Value Per 1g of Dry M. Oleifera Leaves	Amount of Dry Leaves Needed to Meet Human Needs [g]	Amount of M. Oleifera plants to produce required amount of dry leaves
Protein [g]	51	0.094	542.55	121.74
Energy [calories]	2000	64	31.25	7.01
Potassium, K [mg]	3500	3.37	1038.58	233.03
Calcium, Ca [mg]	1000	1.85	540.54	121.28
Vitamin A [µg]	900	3.78	238.10	53.42
Vitamin C [mg]	400	0.517	773.69	173.60

## Research Team

Team: Benjamin Hufendick, Deanna DeMattio, Nick Spadaro, Ruben Rosa-Polonia, and Timeo Williams

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## Introduction

- NASA predicts in less than 30 years we will have astronauts exploring Mars
- It costs \$10,000 to put one (1) pound of payload into Earth's orbit, which is why it is so important to grow food on the planet
- Using hydroponic systems saves up to 80% more water than traditional soil based agriculture
- The Sojourner Rover on the Pathfinder mission was able to produce 900 Watt-hours of energy per Martian sol
- Using two (2) 395 Watt solar panels, four (4) hydroponic systems can be powered 24/7 in the designed greenhouse
- Moringa, Goji Berries, Kale, Chia, Hemp, Sweet Potatoes, and Bamboo contain a complete necessary set of amino acids, vitamins, minerals, fiber, carbohydrates, and other nutrients for a balanced diet
- A greenhouse can be above or below ground on Mars. Below ground, light will be funneled in from the surface, rather than artificial lighting
- Further research is required to focus on the atmospheric conditions, solar radiation, dust storms, temperature variations, and different seasonal lengths that may effect the growth of plants

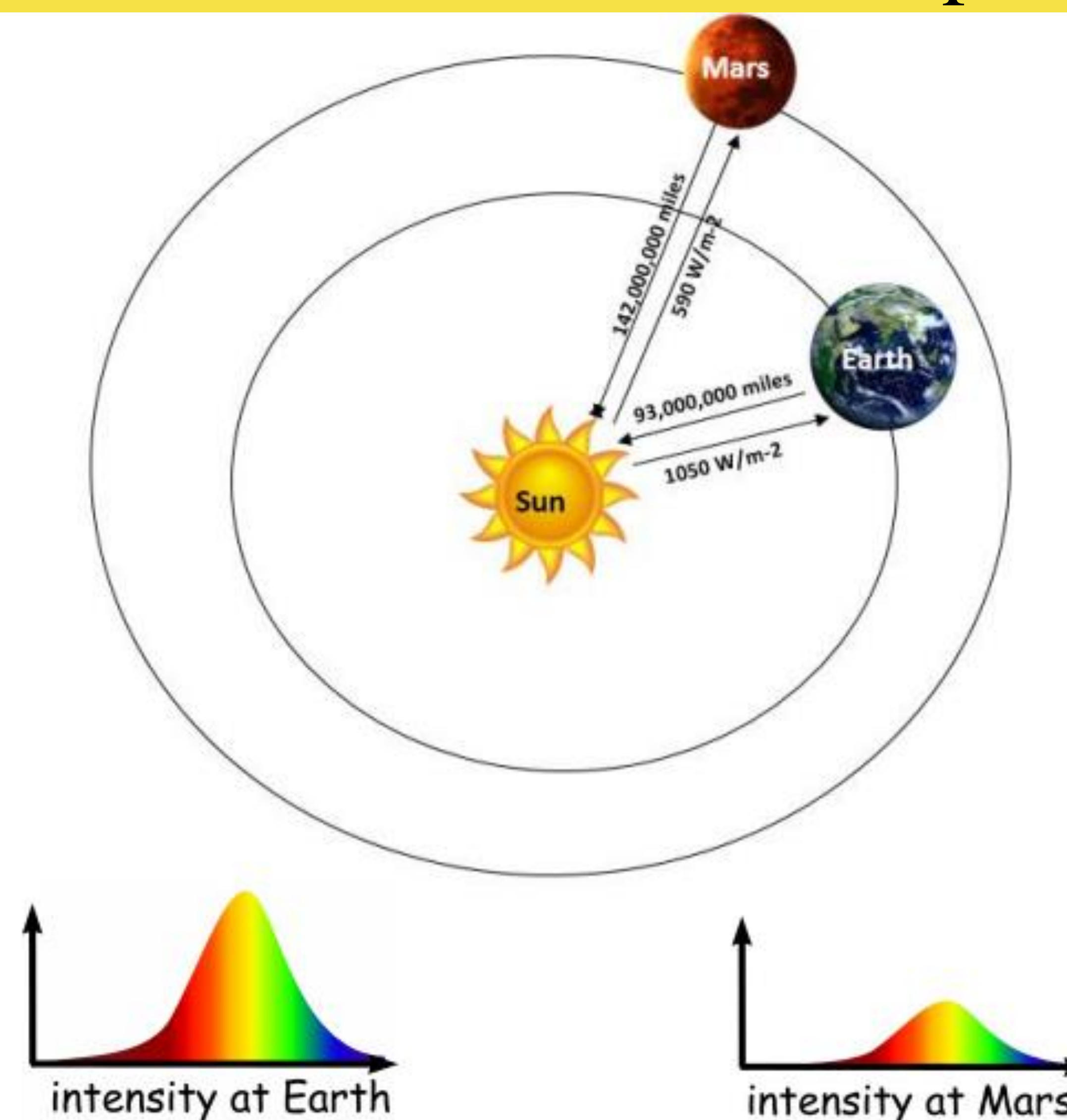
## Methodology

- Use a shade tent to cover the greenhouse and solar panels so only 590 W/m<sup>2</sup> of sunlight is received by both the plants and solar panels.
  - 2 Jinko Solar Panels will be placed on the ground optimizing sunlight
- Use four hydroponic systems to save water and efficiently monitor the growth of plants.
  - Vertical Tower – Goji Berries
  - Raft System – Sweet Potatoes
  - NFT Table – Kale
  - Dutch Bucket System – Chia, Moringa, and Bamboo
- Use Monnit Wireless Sensors to get 24/7 measurements of temperature, humidity, CO<sub>2</sub>, and sunlight.
- Plants will grow for 1 year with incremental harvests to determine the amount of growth for that period.
  - Plants will be dehydrated then weighed to record an accurate measurement of weight/growth
- The weights and growth will be compared with the USDA Food Composition Database to determine nutritional content of the plant grown in a hydroponic system with reduced sunlight versus traditional agriculture receiving full sunlight.



Figure 1: Greenhouse and solar panels

## Mars – Sun Relationship



	Earth	Mars
Length of Day	24 hours	1 sol = 24h 40m
Length of Year	365 days	668.6 sols
Axial Tilt	24.3°	25.2°

## Mission to Mars

The size of the greenhouse will be adjusted to feed x-amount of astronauts

The food grown will provide a complete diet for a year

The systems will require minimal attention once built

The greenhouse can be located above or below ground

Systems will only use solar power to operate