

# 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 Goji Berries, Moringa, Kale, Chia, Hemp and Sweet Potatoes. 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  $590 \text{ W/m}^2$  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

Hydroponic *M. oleifera* was tested in a hydroponics system under Mars ambient lighting conditions of  $590 \text{ W/m}^2$  for a full year. The plant tolerated repeated stem cutting ( $n = 20$ ), with rapid regrowth. A dry leaf yield of  $0.18 \text{ g/day}$  per plant was observed. This yield and the significant nutrient content of *M. oleifera* are of interest, representing the production of significant food value (Table 1), per the USDA reference data for *M. oleifera* nutritional content.

Nutrient	<i>M. oleifera</i>
Protein	80 mg
Energy	2.4 kj
Potassium	2.8 mg
Calories	1.6 mg
Vitamin A	63.8 IU
Vitamin C	0.4 mg

Table 1: Nutrient content in grams per plant per day

## Researchers

Primary Investigator: Deanna DeMattio

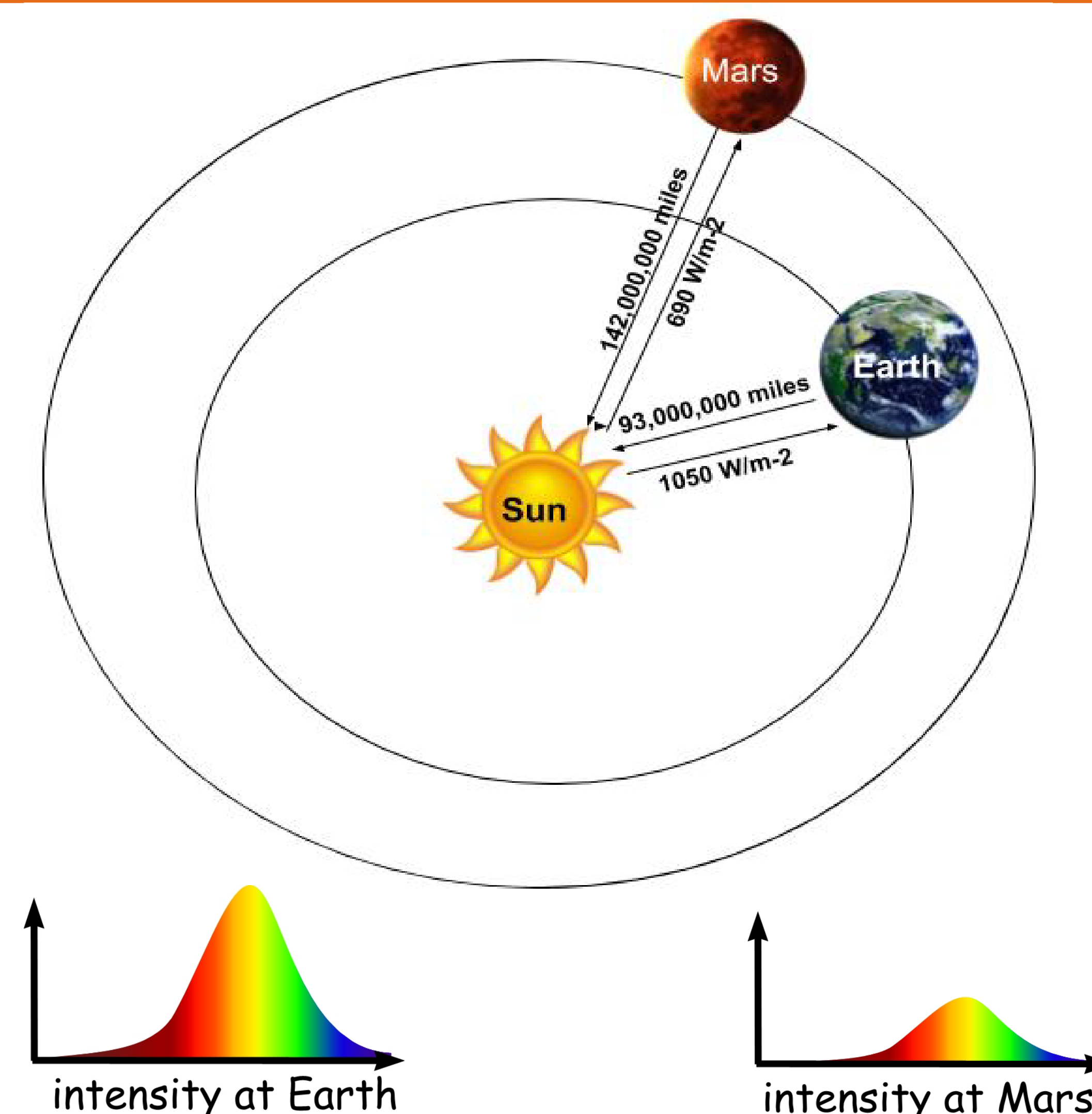
Team: Nicholas McGuire, Ruben Rosa Polonia

Faculty: Rafael Rodriguez, Kevin Rigby

## Introduction

- NASA predicts in less than 30 years we will have astronauts exploring Mars
- It cost \$10,000 to put a pound of payload into Earth's orbit which is why it is 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 watts- hours of energy per martian sol using
- Using two 395 watt panels, four hydroponic systems can be powered 24/7 in the designed greenhouse
- Moringa, Goji Berries, Kale, Chia, Sweet Potatoes, and Hemp contain a complete necessary set of amino acids, vitamins, minerals, fiber, carbohydrates, and nutrients for a balanced diet
- A greenhouse can be above or below ground on Mars. Below the ground light will be funneled in rather than using artificial lighting
- Further research is required to focus on the atmospheric conditions, solar radiation, dust storms, temperature, and seasons that effect the growth of plants

## 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°

## Methodology

- Use a shade tent to cover the greenhouse and solar panels so only  $590 \text{ W/m}^2$  of sunlight is received by both the plants and panels
  - 2 Jinko Panels will be placed on the ground optimizing sunlight
- Use four hydroponics 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, 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 harvest to determine the amount of growth for that time period
  - Plants will be dehydrated then weighted to record an accurate measure 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 versus traditional agriculture.



Figure 1: Greenhouse and Solar Panels

## Mission 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