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. To support these missions, we will evaluate multiple hydroponics systems to grow a complete necessary set of amino acids, vitamins, minerals, fiber, carbohydrates, and nutrients for a balanced diet. The hydroponics systems will be designed in a greenhouse 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^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.

Introduction

- NASA predicts astronauts exploring Mars in less than 30 years
- It costs $10,000 to put one (1) pound of payload into Earths orbit, which is why it is so important to grow food on the planet
- Hydroponic systems saves up to 80% more water than traditional soil based agriculture
- The Sojourner Rover on the Pathfinder mission produced 900 Watt-hours of energy per Martian solar power
- Two (2) 395 Watt solar panels and four (4) hydroponic systems can be powered 24/7 in the designed greenhouse
- Moringa, Goji Berries Kale, Blueberries, Elderberries, Sweet Potatoes, Bok Choy, Ginger and Bamboo contain a complete necessary set of amino acids, vitamins, minerals, fiber, carbohydrates, and other nutrients for a balanced diet
- 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

1. Use a shade tent to cover the greenhouse and solar panels so only 590 W/m^2 of sunlight is received by both the plants and solar panels.
   a) 2 Jinko Solar Panels will be placed on the ground optimizing sunlight
2. Use four hydroponic systems to save water and efficiently monitor the growth of plants.
   a) Vertical Tower – Goji Berries, Elderberries and Kale
   b) Raft System – Sweet Potatoes, Bok Choy, Ginger, Blueberries
   c) NFT Table – Kale
   d) Dutch Bucket System – Moringa Oleifera
3. Use iMonnit Wireless Sensors and Blue Lab Monitor to get 24/7 measurements of temperature, humidity, CO2, sunlight and pH.
4. Grow for 1 year with incremental harvests to determine the amount of growth for that period.
   a) Plants will be dehydrated then weighed to record an accurate measurement of weight/growth
5. Compare growth and weight with the USDA Food Composition Database to determine nutritional content of the plant grown.

Figure 2: Greenhouse and solar panels

Preliminary Results

M. Oleifera was tested in a hydroponic system under Mars ambient lighting conditions of 590 W/m^2 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

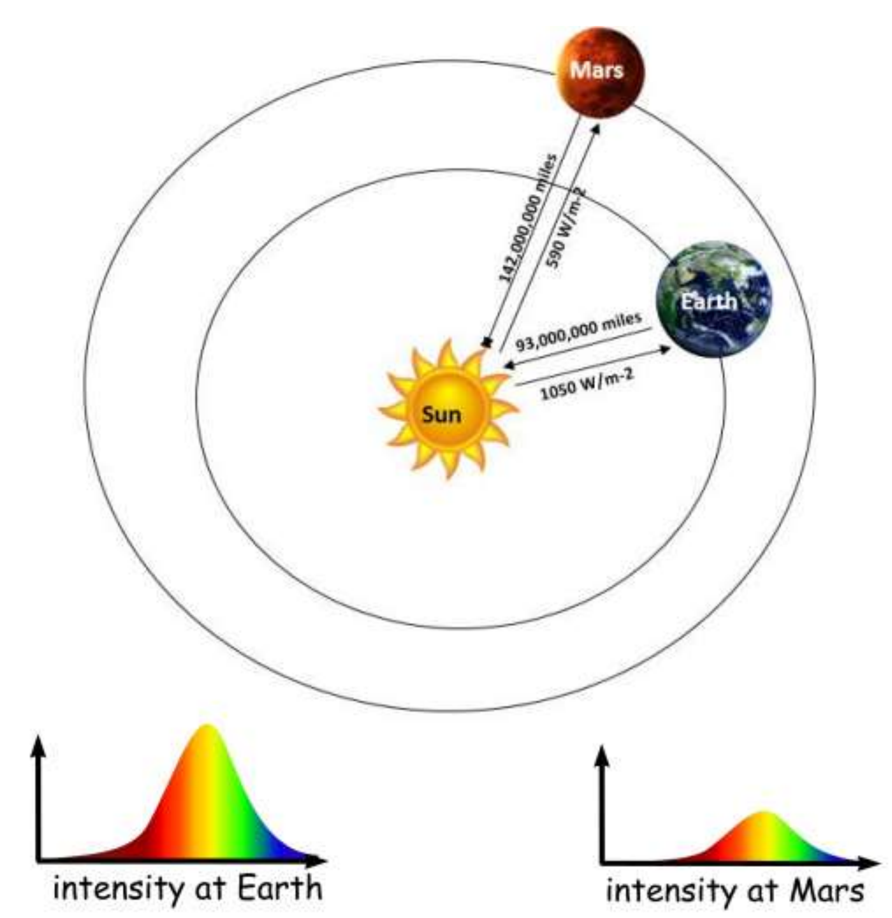
Moringa Oleifera and Goji Berries

Figure 1: Dutch Bucket System and Tower Garden

The Dutch Bucket System is used for the Moringa Oleifera. The nutrient dense water travels from the reservoir to the buckets then back to the reservoir.

The Tower Garden is used for the Goji Berries, Kale and Elderberries. This hydroponic system allows the plants to grow upwards without any interference.

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°

Research Team

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