

The Study of Super Foods for Mars Exploration

Student Research Symposium, November 13, 2018

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, 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 they would on 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.

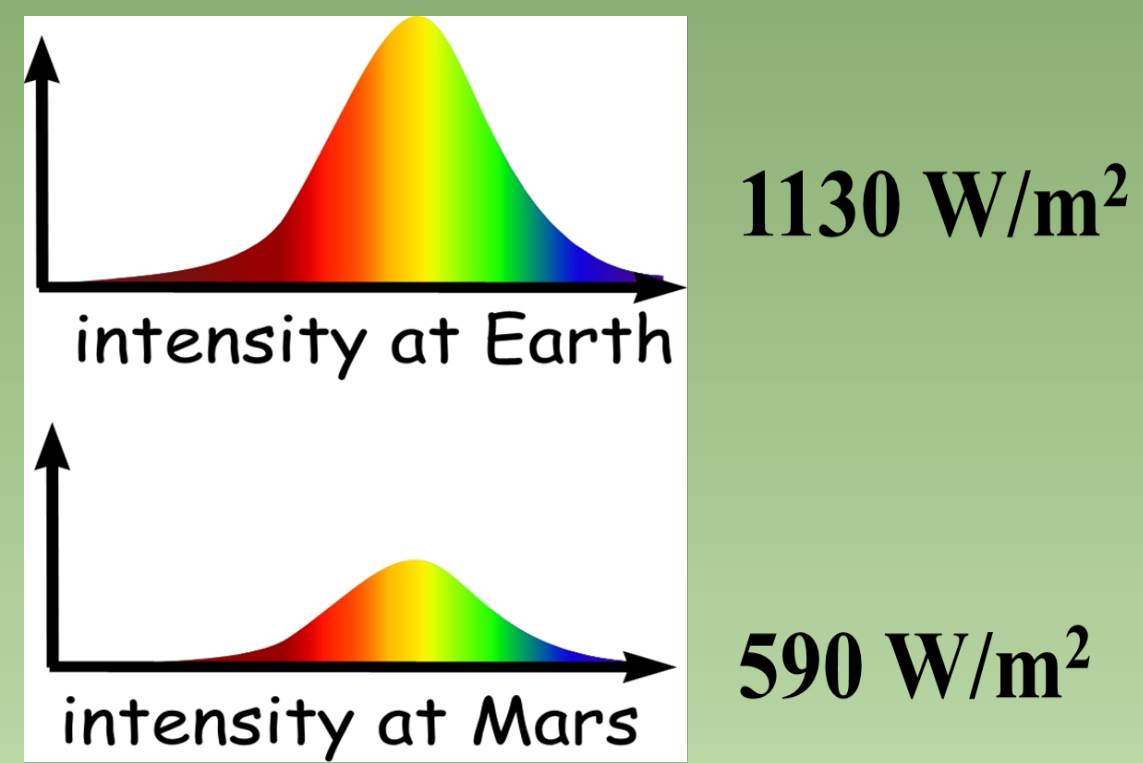


Figure 1: Light Intensity on Earth vs. Mars



Figure 2: The Completed Greenhouse

The Vision

1. The greenhouse will be multiplied to feed x amount of astronauts going to space.
2. The greenhouse will provide a complete diet for a year of exploration.
3. The greenhouse will require minimal labor once built.
4. The greenhouse will either be located above ground or underground with light funneled in.
5. The greenhouse will rely only on solar power to operate.

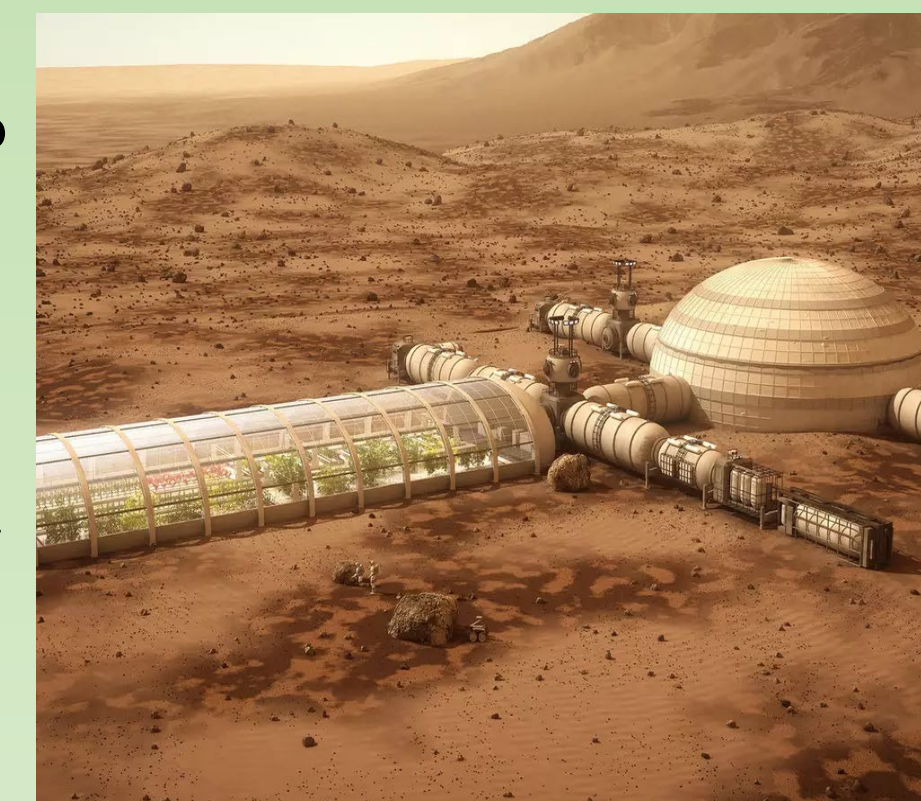


Figure 3: Example Greenhouse on Mars

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Method

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 panels
 1. 2 Jinko Panels will be placed facing East on the roof of the greenhouse
 2. A Shelter Logic Shade Structure goes over the entire greenhouse blocking out 60% of the sunlight
2. Use multiple hydroponics systems to save water and efficiently monitor the growth of plants
 1. Vertical Tower- Goji Berries
 2. Raft System- Sweet Potatoes
 3. NFT Table- Kale
 4. Dutch Bucket System- Chia, Moringa, Bamboo
3. Use Monnit Wireless Sensors to get 24/7 measurements of temperature, humidity, CO₂, and sunlight
4. Plants will grow for 1 year with incremental harvest to determine the amount of growth for that time period
 1. Plants will be dehydrated then weighted to record an accurate measure of weight/growth
5. 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

Previous Work

Hydroponic *M. oleifera* was tested in a hydroponics 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 0.18 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



Figure 4: Hydroponic Moringa System 2016-2018

Construction

Day 1-3



Day 4-5



Systems

NFT Table



Dutch Bucket



Tower Garden



Raft System



Acknowledgments

IGNITE Office of Undergraduate Research
 Dr. Kevin Rigby
 Chris Ziolkowski