The Study of Moringa Oleifera Under Mars Lighting Conditions

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Abstract

Agriculture in enclosed and buried structures on Mars will enable astronauts to conduct extended surface exploration missions. We evaluated a deep-water culture indoor hydroponics system to grow *Moringa oleifera*, a nutrient- and antioxidant-rich plant with leaves containing all nine essential amino acids. After initial aquaponic growth and 3 prior harvests, the lighting intensity was set to 590 W m^{-2} in a twelve hour on/off cycle, in normal indoor atmosphere. This simulates an ambient light collection and reflection system on Mars illuminating an insulated, pressurized underground chamber for agriculture. All plants (N = 32) were harvested 17 times over a 9 month period at regular intervals, when plant heights reached an average of 0.9 m. Consumable leaf yield averaged 0.18 dry g per plant per day. Data suggest *M. oleifera* as a perennial hydroponic crop is possible under reduced illumination, and is a candidate food source for Mars explorers.

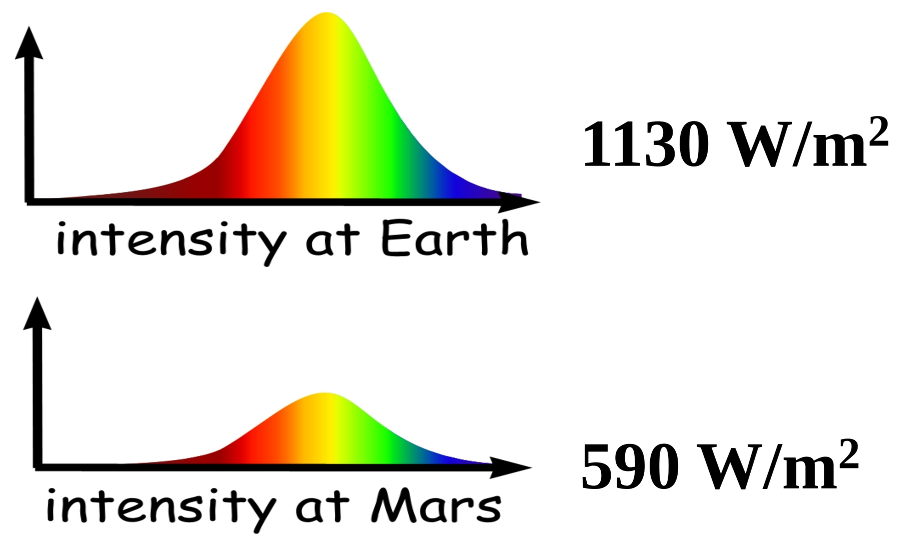

Figure 1: Light Intensity on Earth vs. Mars

Introduction

Mars has the potential for human colonization. If a small variety of crops providing complete nutrition could be grown in Mars ambient light, this will support exploration and settlement. The purpose of this research is to determine if the tree *M. oleifera* could provide yield over an extended period of cultivation in Mars light conditions in hydroponic culture. The *M. oleifera* tree is a nutrient-rich "super food" native to subtropical areas on Earth.. An indoor recirculating hydroponics system is used to eliminate soil, conserve water, and supply nutrients. The lighting used is comparable to the light intensity on Mars at solar noon. Over 15 months, thirty two plants grew in deep-water raft culture, beginning from seed in aquaponic culture (including fish), then transitioning to hydroponic nutrient supply (without fish).

Method

Moringa oleifera was grown from seed for several weeks in an aquaponic system under Earth lighting conditions to verify the plants would sustain growth in indoor deep-water raft culture. Planting density was 18 tree m^{-2}

1. The lighting changed from 1130 W m^{-2} to 590 Wm^{-2} in January 2017
2. Harvesting was done every 23 days, on average.
3. The plants were cut back to 0.46 m and the stems and leaves collected.
4. The stems and leaves are separated by hand in order to compare the individual growth.
5. The stems and leaves are then dried in a commercial dehydrator to remove moisture at 120 °F for 24 hours (not optimal for nutrition)
6. The dry weights of dried edible leaf and inedible stem were measured

Plant Culture Conditions

1. The plants were fed 750 mL a 2-1-6 commercial hydroponic nutrient solution every 7 days, on average.
2. Tap water was added to replace evaporation. System water was maintained at 75.4 °F average by thermostat heater.
3. The average pH for the growth period was 5.8, and was allowed to vary without control during the growth intervals.

Figure 2: Harvest of Stems and Leaves

Results/Conclusions

Hydroponic *M. oleifera* can sustain growth 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. Further work to optimize harvest interval and hydroponic conditions is needed.

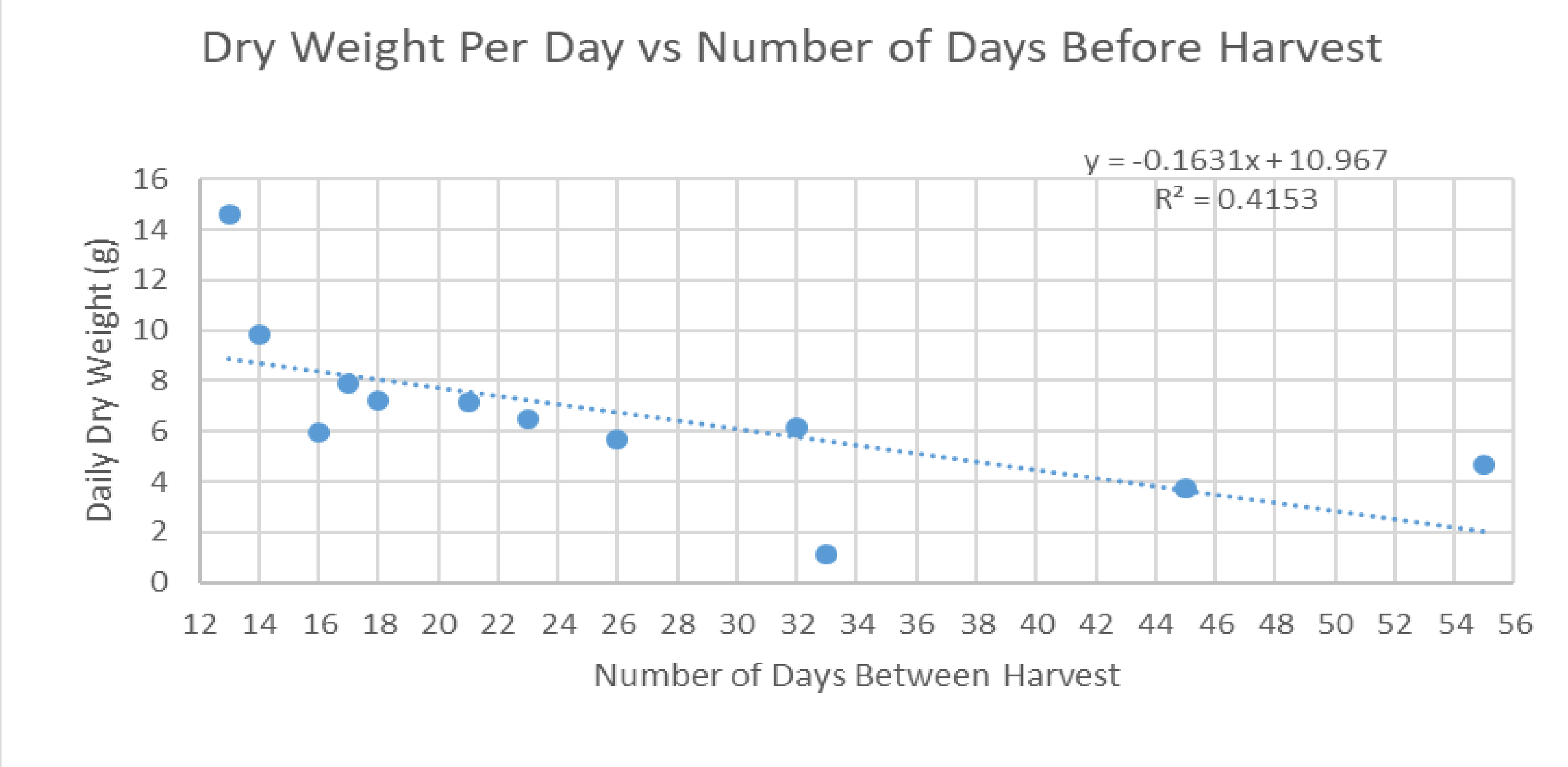

Figure 4: This plot shows the amount of dry weight in grams that accumulates per day in relation to the amount of days in between harvests.

Nutrient	*M. oleifera,* content per dry g leaf
Protein	80 mg
Energy	2.4 kj
Potassium	2.8 mg
Calcium	1.6 mg
Vitamin A	63.8 IU
Vitamin C	0.4 mg

Table 1: Nutrient content of *M. oleifera* in grams per plant per day.

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Figure 3: Timeline of Plant Growth in One Harvest