Martian Growth Systems Experiment: Testing Hydroponics, Aeroponics, and Soil Growth Systems on Mars

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Abstract

Three main growth systems have been proposed for Mars: hydroponic, aeroponic, and soil (Grush, 2018). The Martian Growth Systems Experiment plans to discover which growth system is the most optimal for Mars. In the long term experiment, long-lived and short-lived plants will be used. However, in a short term experiment, only short-lived plants will be used. Materials include a greenhouse, seeds, life support, waste management, and a robotic automation system (Volponi, n.d.). When combined these systems will use a total of 24697 watts of power, which will be supplied by a nuclear reactor. Astronauts will not be expected to tend to plants all day, so much of the experiment will be automated (Volponi, n.d.). The expected best system is aeroponics, like on Earth (Mason, 2018).

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**Introduction:**

There are three proposed ways to grow plants on Mars: hydroponics (growing plants in a water substrate), aeroponics (growing plants with no substrate), and soil (growing plants the traditional way)(Grush, 2018). Which one is the best, however? This experiment plans to answer that question. Once on Mars, seeds from various plants will be planted in aeroponic, hydroponic, and soil systems. A short term experiment would require the use of fast-growing, short-lived plants. A long term experiment would have both long-lived and short-lived plants. Materials include a greenhouse with life-support, seeds, and a robotic system. In total, this experiment will use 24697 watts (Volponi, n.d.). Even though much of this experiment will be automated, astronauts will still have to check-in at least once a day to perform maintenance. Aeroponics is predicted to have the fastest growth rate compared to hydroponics and soil (Mason, 2018).

**Long term vs. Short term:**

A short term experiment like this would require plants that have a short lifespan. Conversely, a long term experiment would have plants with both longer and shorter life cycles. The ones with shorter life cycles could get repeats for redundancy. Other than that, there is not much difference between the long term and short term experiment testing Martian growth systems.

**Materials:**

An experiment like this would require a greenhouse with hydroponics, aeroponics, and Martian soil gardens (Grush, 2018). To clean the soil of toxic compounds, a strain of bacteria will be bioengineered (University of California, 2017). Various seeds, such as those from cabbage, carrot, chard, celery, green onion, lettuce, and peanut will be included (Volponi, n.d.). The greenhouse will have to include life support for the plants, like air circulation, dehumidification, heating, irrigation, waste management, and lighting (Granath, 2017). Irrigation will be covered by the Water Recovery System (WRS) currently used on the ISS. The waste management will include “a sterilizer… drier, condenser, sizer, batch incinerator, filter, and storage tank” (Volponi, n.d.). For lighting, light-emitting diodes (LEDs) will be used, as they give off the best light frequencies for plant growth, and can last longer compared to high-pressure sodium bulbs or fluorescent tubes, two lights commonly used by gardeners. Also, there will be a nutrient-rich solution to feed the plants. Specifically, plants will need an “initial ionic solution[,]… replenishment ionic solutions,” and of course, water. To automate some of the processes, a multi-purpose robot could plant seeds and harvest crops (Volponi, n.d.).

**Power:**

The life support system will use 2380 watts (W). The thermal regulation system will use 578 W, the “Command and Data Handling” system responsible for collecting data and automation will use 39 W, and the greenhouse subsystems will use 21700 W. These subsystems include waste management, robotic assistance, growth support, plant storage, irrigation, light, and nutrients. This brings the power to a total of 24697 W (Volponi, n.d.). This power will be supplied by a nuclear reactor. This is because other forms of energy are unreliable. Plants are fragile and if heating or lighting were cut off, they would die. Solar energy can be cut off by Martian dust storms. Wind energy and geothermal will not work because of Mars’s thin atmosphere and cold core, respectively. Therefore, nuclear power is the most reliable way to support plant growth in a Martian greenhouse (Kurzgesagt - In a Nutshell, 2019).

**Time Factors:**

Astronauts will not have to maintain the plants throughout their lifespans because much of the growth can be automated. Watering, fertilizing, recording data, planting, and harvesting can all be done with robotic assistance (Volponi, n.d.). Martian colonists will have to check on the plants each day, to perform any operations that cannot be automated.

**Theorized Results:**

Because plants have different lifespans, results at definite times, like three months, or 12 months, cannot be predicted. For example, potatoes have a lifespan of about 80 to 150 days, while peanuts last one year (GeoChemBio, n.d.; National Peanut Board, n.d.). Results will also vary from plant to plant. However, general trends can be predicted. At ⅓ of a plant’s lifespan, aeroponics will be the predicted slowest, because it has yet to establish its root system. The soil and hydroponic systems will grow plants more quickly at the early stages. At ⅔ of a plant’s lifespan, aeroponics will most likely have caught up with the other two. The hastened growth is due to the amount of oxygen available to the plant in an aeroponic environment. Then, finally, at the end of a plant’s life, aeroponics will be the tallest. The next tallest will be hydroponics, then soil (Mason, 2018).

**Conclusion:**

During the long term version of the Martian Growth Systems Experiment, long-lived and short-lived plants will be used. A short term version would only use short-lived plants. It will require a greenhouse with life support systems and robotic assistance, as well as seeds. It will use up a total of 24697 watts of power, which will be generated by a nuclear reactor (Volponi, n.d.). Most of the experiment will be automated by computers and robots, so astronauts will not have to spend their days gardening. Theoretically, hydroponics should grow the fastest, like on Earth (Mason, 2018). The farther humans travel from Earth, the more likely it is that plants will be used. So when humans finally reach the stars, their terrestrial friends will be right there with them.