Human Viability on Mars based on Plant Biology

Technical Report

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Abstract

The purpose of this experiment is to essentially prove or disprove the viability of a permanent human settlement on the planet Mars. The experiment is a proof of concept and will test the praxis of Mars settlement ideas. There will be two primary parts to the experiment: data collected on the plants in the face of microgravity and Mars’s gravity, and data collected on the effect of radiation on plants. The viability of the soil with regards to some plant species will also be tested. The exact location of the landing site is to be determined. The power and material requirements, short term v.s. long term, time factors, and theoretical results at certain intervals will be discussed. After the experiment, a critical discussion on whether a human settlement on Mars is viable based on new understandings of plan biology will be had and may determine future Mars exploration efforts.

*Keywords*: plant, viability, gravity, radiation, soil, human settlement, experiment

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NASA and other space-faring agencies have been actively looking at Mars to create a viable human settlement sometime in the future. The primary issue with this is that there is no experience regarding human Mars exploration that NASA has collected. Naturally, NASA has a lot of planetary data on Mars, but no biological data exists since no biological life has ever been found on Mars or truly taken to Mars. Human Viability on Mars Based on Plant Biology (HVMPB) aims to see whether plants, in general, can truly exist on Mars, whether through artificial means or not. If agriculture is possible on Mars, then theoretically, a human settlement, and a civilization later on, is possible. HVMPB is crucial to understanding whether a settlement is really possible and sustainable.

**Design Differences (short term v.s. long term)**

The experiment is to be conducted over a 22-32 month period (in Earth months), depending on how long it takes for the spacecraft to reach Mars. This experiment would be impossible to conduct on Earth, or at least extremely difficult to be done accurately. Mars soil could be replicated for one part of the experiment, but Mars’s gravity and radiation would be difficult to be simultaneously simulated in an Earth laboratory. Earth’s orbit would yield different results than Mars due to the lower gravity and lower radiation since the International Space Station lies partially in Earth’s magnetosphere and atmosphere, receiving some protection from radiation (Tran, 2019). A short term experiment would not accurately tell whether a plant can survive long enough to grow and yield crops. A plant that would only survive for one month is useless; a longer study must be taken on Mars in order to ensure a precise estimate on the longevity of various plants. The Mars surface provides the best simulation of potential agriculture on Mars in the future.

**Materials and Power**

Excluding necessary materials for the actual base and people operating it, there are some necessary materials for the experiment. The actual plant seeds would be needed. Some possible candidates for plants include kale, carrots, lettuce, sweet potatoes, onions, dandelions, and hops, as they have been proven to grow in Martian soil, with some adjustments (Cartier, 2018). To measure plant health, some tools such as a refractometer and calcium meter are crucial to determine the nutrients in the soil and the nutrient uptake of the plants (Kempf, 2015). In place of polycarbonate panels or glass for a greenhouse, vertical farming would be used, so some housing material could be used to actually contain the plants and soil. A significant amount of water would be needed if Martian soil is used due to the soil drying out extremely quickly (Cartier, 2018). This same experiment also found that vermiculites, or even shredded cardboard, could fix the issue of the Martian soil being too tightly packed since they would aerate the soil. Some artificial light source would be needed to replicate Earth-like conditions. LED lights have been viewed by NASA as being efficient and powerful enough for plant growth and are best suitable for the task (Herridge, 2012). Fertilizers would also be useful and waste materials could be converted into fertilizers to mitigate the material need. To measure radiation on the plants, some specialized Geiger counter could be used. Some plants would be used on Mars, others on the way to and from Mars. The plants going to Mars would need to be preserved in cytostasis, requiring the use of cryogenically freezing the seeds and therefore, a cryogenics chamber. Gravity should be relatively constant along Mars, so there is no need for use of instruments to measure gravitational force. The base itself would have its own power requirements but the experiment would most likely not require much power. On Earth, a typical vertical farm requires 3,500 kWh per square meter per year with a standard greenhouse requiring about 250 kWh per square meter per year for lettuce (Jenkins, 2020). Because Mars has no atmosphere, the power estimate is probably larger than just 3,500 kWh as filtration would require a fair amount of power as well.

**Time Factors**

As stated previously, the mission would take between 22-32 months. The time spent on Mars would be 12 months with the travel time going from Earth to Mars would take 5-10 months. The experiment could actually be started on the trip to Mars and continued when the crew leaves back for Earth. This would yield data not for a Mars settlement, but rather, for the trip to Mars and back. That data is crucial in order to understand whether plants can grow on the space travel trip. It is not entirely certain whether the seeds would germinate in the same amount of time like they would on Earth, so it cannot be determined how long each growth stage would take. It can be assumed that growth phases would be delayed. It is certain, though, that if the plants survive, the personnel would have to spend a large amount of time watering and maintaining the plants and spend considerable time running tests on the plants to observe their health. Approximately four hours would be used everyday to maintain the plants, with three hours daily used intermittently to run tests. The rest would be used to run the facility and exercise to maintain muscle mass.

**Theoretical Results at 3, 6, 12 month intervals**

Although there is still much to know about Mars and its growing capacities, results can be theorized at 3, 6, and 12 month intervals. There is some evidence as to what plants go through radiation. Plant growth will decrease, seed germination reduced, and lifespan reduced as a result of radiation (Miller, 2015). Examining Chernobyl, plants also sustained through decades of greater environmental radiation by having an 32% greater betaine aldehyde dehydrogenase than plants outside the affected area (Fairless, 2017). Absence of gravity seems to have a small effect on plant growth (BMCL, 2012). Prolonged exposure has not been previously studied, however, so it is unknown how the plant would grow past its initial growth stages. Martian soil does fulfill many absolute requirements that plants need to grow, so there is definitely a good chance that the soil will contribute to continued growth (Jordan, 2015). With all of this information, it is very probable that most of the plants will survive up to 3 months on Mars and some will survive the entire trip to Mars. At 6 months on Mars, some would survive. Finally, at 12 months, between 20% and 35% plants would most likely survive but this is a very rough estimate and more research would ultimately be needed. Going back to Earth would yield similar results to the trip to Mars, theoretically. The overall experiment would most likely show that it is possible to grow plants on Mars with some adjustments.

**Conclusion**

Having a settlement, or possibly an entire civilization, on Mars would yield a vast amount of knowledge about the universe that could be used to better humanity overall. But, in order to ever achieve such an accomplishment, plant biology must be better understood in space and on Mars. Because of the nature of the resources and expenses of the experiment, other experiments could easily be done in conjunction with HVMPB. This study has great potential for humanity and could potentially be used to help treat current world hunger problems by learning about the inherent qualities of plant biology. Ultimately, more research is needed to make any confirmations and predictions but this study is a crucial step forward in the path of human exploration.

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