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Hydroponics to Survive on Mars

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Abstract: Background: Determining the requirements and availability of food when we move to Mars would be a huge problem as most of our other alternative to food growth on Mars does not have a good cost-to-benefit ratio. Carrying or moving food for us to Mars would be environmentally implausible and
Materials and Methods: The traditional method of hydroponics was used with the alteration of making the atmosphere suitable for Mars, with the required lighting, pressure and temperature was setup to recreate growing plants on Mars .
Results: The results obtained showed lower weight and nutrient value thatn the control specimens , the plants that were grown in soil.
Conclusion: The lower results can be attributed to the
Keyword: Hydroponics, Aeroponics, Mars

I. INTRODUCTION

Mars, the "Red Planet ", which is the second largest in our solar system, has been on the forefront when it comes to finding a second home for us Earthlings or the Earth beings. Though it is only half the size of our planet, its history shows that some characteristics like presence of sub-surface water, dirt that has potential to grow life and sunlight exposure which can be sustainable, provides us with a ray of hope, if we did want to occupy it one day. Mars has been explored by various unmanned spaceships from the Mariner to NASA's Viking.
Rovers have been sent across to explore the planet by the United States and China. Famous companies like Elon Musk's SpaceX , Jeff Bezos's Blue Origin and Richard Branson's Virgin Galactic are also trying to conquer space travel. With mighty interest like this, it is time that we look into the survival aspects of the planet.
Efforts are also being taken to make even its moons, Phobos and Delmos, habitable given that they also have the regolith surface which can be used for crop growing.
But moving to Mars would require a plan from basic up, from your oxygen, food, water to the required spare tools and construction equipment that would be necessary to build your home on the surface autonomously.
From getting the fundamentals correctly, there are other social structures that are present on our current planet which would have to be replicated on the Red Planet too.

II. MATERIAL AND METHODS

When planning to move to Mars the first thing required in the inventory is food, since the logistics of bringing food from Earth is not feasible in long term. If we are planning to grow food on Mars, the information that we have currently is minimal and not decisive. Let’s preface it by saying, humans require 1500 calories per day on an average to survive and maintain health and a regular potato contains 110 calories, one cup (130g) turnip contains 36 calories, 1 cup of radishes(116 g) contain 18 calories and 1 cup of lettuce shredded (36 g) contains 5 calories.
One study recreates the farming here on Earth by simulating Mars’s crust as it is largely weathered basaltic regolith soil mainly containing salts like sulfates and perchlorates [1].
Based on the data obtained from orbiting spacecraft, rovers and landers, the study comes to the conclusion that Mars is a basalt-covered world, owed to its past volcanic activity. The crust is basaltic, with very limited siliceous rocks and no rocks critically under saturated in silica.
Basaltic crust on earth can be found at the continental flood basalts of India, the Chilcotin Group in British Columbia, Canada, the Parana Traps in Brazil, the Serbian Traps in Russia etc., .Analyses of basaltic regolith soil has found that the macro nutrients found are - C, H, O, N, P, S, K, Mg, Na and Ca and the minor elements found are - Mn, Cr, Ni, Mo, Cu, Fe and Zn. The main limiting factor for using basaltic soil in agricultural use is its low nutrient bioavailability and poor water-holding capacity due to absence of organic food.
Another study [2], recommends two types of Martian farming methods:

1) Creating a thriving microenvironment for nitrogen fixing bacteria, by fusing opaline silica (found in volcanic areas of Mars) with Martian topsoil. Though it might be the easier method, there various other challenges, from the depletion of resources that would be required for harvesting silica can be used in other important areas like oxygen filtration or the presence of silica in a relatively inhabitable zone in Mars (Northern Plains), there is no water available in the Northern Plain area.
2) Hydroponic farming, a method currently used by our astronauts, growing plants in water by adding nutrients in it. Here the nitrogen fixing bacteria will attach directly to the roots and survive to produce nitrogen on Earth. The challenge faced in this method would be the nitrogen fixing bacteria does not show the best survival under Martian conditions and gathering of other minerals like potassium, nitrogen and calcium gathering would be difficult.

A. Procedure Methodology

After settling to test out the hydroponic farming method, a well-designed environment that can mimic Mars's environment in terms of temperature and pressure was created. The crops that were selected to be harvested were All lipid parameters were quantified on samples collected in the fasting state. Potatoes, sweet potatoes, radishes, and soya beans. The above crops were selected as NASA recommends them for their carbohydrate and protein content.

For ensuring the lighting conditions of Mars, red and blue LED lights were used and to prevent from ultraviolet or any other harmful radiations, the plants were put in a protected and pressurized environment.

Amongst the three versions of hydroponics- Wick system, Floor & drain hydroponic system and Water culture hydroponic system, we have chosen the Water culture hydroponic system. In this method, plants are continuously submerged in the nutrient-rich water tank throughout the day. Planted containers float on a "raft" or are suspended directly overhead, so the roots can extend down into the water. Small blubber is kept inside the vessel or tank to aerate the container and prevents the water from being stagnant.

The further step-by-step instructions are:

1) The pots were placed on the container lid upside down , and the outlines of the pots were drawn on the container lid and ensured that there are no overlaps, this was done to ensure there is enough space for the pots in the container lid
2) Next a small circle was cut at the centre of each circle that that was initially drawn about the size of every pot's bottom. And then perpendicularly cut from this small circle to the bigger circle, the idea was to push the pots into the container mid-way from the lid
3) A hole was made on the top of the container and to run an airline through there. This hole was kept airtight with cotton and cork clogging, to avoid sunlight exposure, thereby the evaporation
4) The air stones were placed inside the container after washing to eliminate any contaminants and were connected to the airline and then to the air pump.
5) Initially the nutrient solution used was of 10-10-10 composition, with an even balance of Nitrogen , Potassium and Phosphate. Later, based on previous studies, the composition of the required nutrients was added to ensure better growth and germination of the seeds.
6) The blubber was used to start aerating the water, once the container was filled in.
7) Rockwool shrink a little, so a little more was added. This would not have been the case had we used fired clay or organic mediums. Some amount of pot full of medium was put into a large bucket, bowl, etc. Filled this bowl with water and estimated how many gallons were added. Then the appropriate amount of nutrient solution was measured. The medium was completely soaked in the water.
8) While the medium is soaking, plants were sanitized and ensured the dirt is off of them, while taking care not to damage the root system. A little bit of growing medium was placed in the bottom of a pot, then the plant was placed in and fill the pot with your medium.
9) The lid was put on the container, and pressed the pot into an open hole. Same process was repeated for the rest of your plants.

In every step, care was taken to ensure that the condition under which experiment was conducted was closest to the Red Planet's environment.

B. Statistical Analysis

Data regarding the plants grown and their nutrient value was analyzed based on their weight. The smallest plants required about 2 Liters of water while the larger plants required between 4 Liters – 10 Liters of water. The temperature of the experiment was kept closest to Mars of -62.7 degree Celsius by placing all the plants inside a refrigerator room, to prevent the freezing of water , an antifreeze was added that lowered the freezing point of nutrient added water mixture.

The pressure of the room where the containers were kept, was at 0.095 psi by introducing vacuum into the room and adding salt to the water in the container.

III. RESULTS

After 6 weeks all the plants were weighed and the numbers of seeds germinated were counted.

Radishes showed 14.0 +/- 2.5 g average weight in bulbs when treated with filtered water. This was 2g less that the control sample that was grown in soil, 16.0 +/- 1.7g. That is a 14.28%

Potatoes harvested after 70 days of planting, after the plants reached 18 inches high the fertilizer was switched to have more potassium. An average potato weighed 182.0 +/- 3.7 g, a 28.5% increase from its soil counterpart that weighed 140 .0 +/- 2.5 g.

Sweet potatoes showed a dry weight of 74.8 $\pm$ 0.9 g which was close to the one obtained from its soil counterpart.

Amongst the plant seeds that were planted potatoes showed the highest germination rate about 72.37%, while sweetpotatoes showed the next highest rate of 63.58%, radishes showed half of spotatoes germination rate 32.78%.

Wheat showed the least germination rate of 10.28% , but none of the lettuce were able to grow after two week, due to which enough samples were unable to take the average weight.

IV. DISCUSSION

When looking at the logistics of taking people to Mars, the amount of water, which is not abundantly present in Mars comes to picture. Our current population number we have is: 7,828,741,002

So number of potatoes per day :

= 7,828,741,002 x 13.6 (the number of potatoes required to fulfil a person's everyday calorie intake)

= 1.0647×10^{11} potatoes

Water required = 1.0647×10^{11} x (28 Litres / 14 potatoes)

= 2.129×10^{11} Litres

= 21,29,41,755.3 cubic meters

Considering hydroponics to be the major source of food also has its own shortcomes as this would be a situation, majority of the resource that we require , water, is not adequately presen in Mars while the thing that is adequately present , the soil will not be used for any use.

And the water that we require would have to be extracted from the soil by microwave heating it. Most of the previous studies referred to Mars farming when the conditions were kept in the same as of Earths and various other requirements like lighting were not taken into consideration.

V. CONCLUSION

Using Mars condition while doing the farming brings us closer to the truth by helping us understand our shortcomes would be once we start doing farming on Mars.

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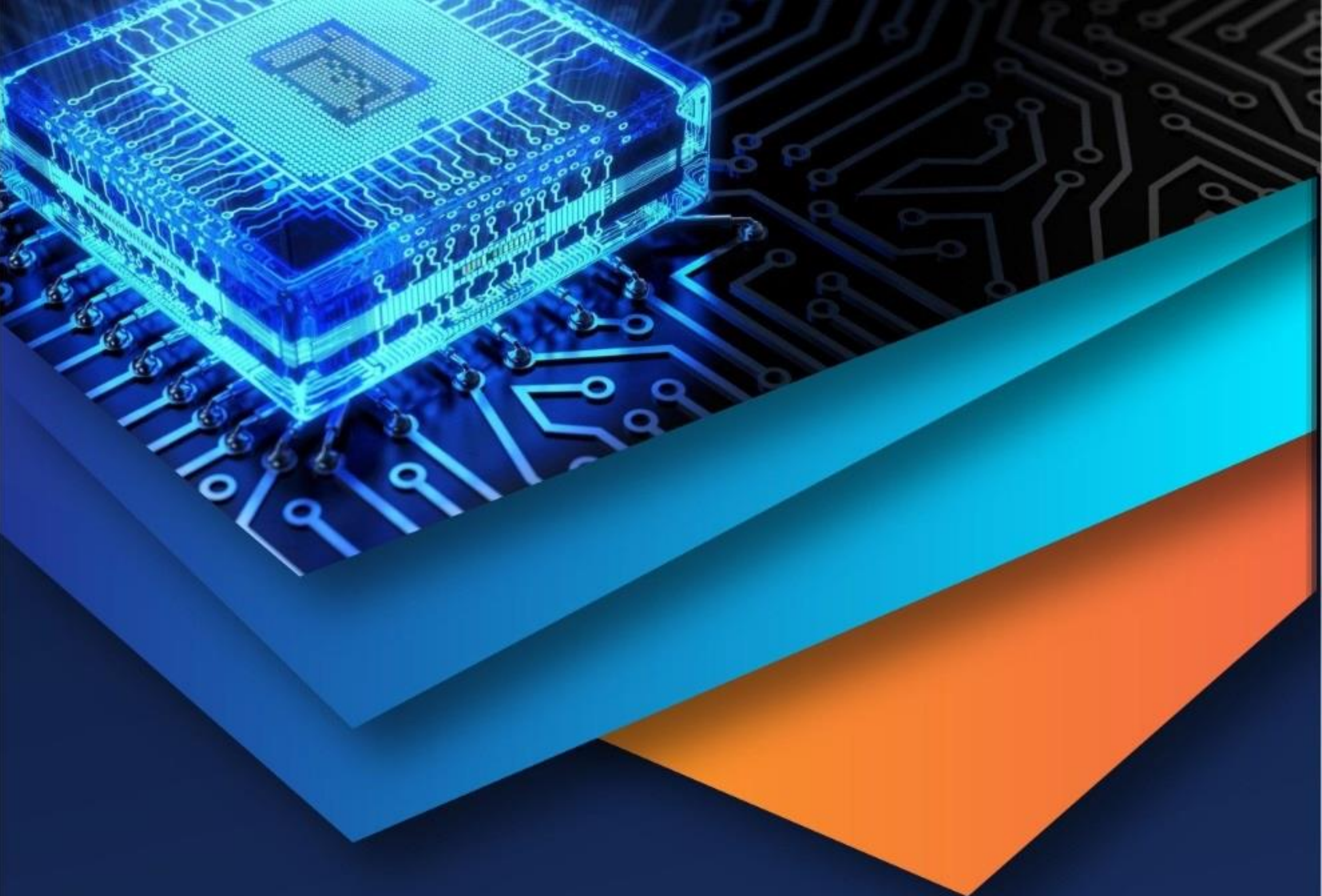

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