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UREAPONICS: A STUDY TO GROW PLANTS IN SPACE

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HISTORY

Plants in space are plants grown in outer space. In the context of human spaceflight, they can be used for food and refreshing the atmosphere. Plants can scrub carbon dioxide and return oxygen, as well as adjust humidity. Plants can be grown in a space garden. Aspects include how plants grow without gravity, and different types of lighting. Growing plants in space may provide a psychological benefit to human spaceflight crews.

REQUIREMENTS FOR PLANT GROWTH-

1) Temperature. Plants grow well only within a limited temperature range. Temperatures that are too high or too low will result in abnormal development and reduced production. Warm-season vegetables and most flowers grow best between 60° and 75° or 80° F. Cool-season vegetables such as lettuce and spinach should be grown between 50° and 70° F.

2) Light. All vegetable plants and many flowers require large amounts of sunlight. Hydroponically grown vegetables like those grown in a garden, need at least 8 to 10 hours of direct sunlight each day to produce. Artificial lighting is a poor substitute for sunshine, as most indoor lights do not provide enough intensity to produce a crop. Incandescent lamps supplemented with sunshine or special plant-growth lamps can be used to grow transplants but are not adequate to grow the crop to maturity. High intensity lamps such as high-pressure sodium lamps can provide more than 1,000 foot-candles of light.

3) Water. Providing the plants with an adequate amount of water is not difficult in the water culture system, but it can be a problem with the aggregate culture method. Water quality can be a problem in hydroponic systems. Water with excessive alkalinity or salt content can result in a nutrient imbalance and poor plant growth. Softened water may contain harmful amounts of sodium. Water that tests high in total salts should not be used. Salt levels greater than 0.5 millions or 320 parts per million are likely to cause an imbalance of nutrients. The amateur chemist may be able to overcome this problem by custom mixing the nutrient solutions to compensate for the salts in the water.

4) Oxygen. Plants require oxygen for respiration to carry out their functions of water and nutrient uptake. In soil adequate oxygen is usually available, but plant roots growing in water will quickly exhaust the supply of dissolved oxygen and can be damaged or killed unless

additional air is provided. A common method of supplying oxygen is to bubble air through the solution. It is not usually necessary to provide supplementary oxygen in aeroponic or continuous flow systems.

5) Mineral Nutrients. Green plants must absorb certain minerals through their roots to survive. In the garden these minerals are supplied by the soil and by the addition of fertilizers such as manure, compost, and fertilizer salts. The essential elements needed in large quantities are nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur. Micronutrients - iron, manganese, boron, zinc, copper, molybdenum, and chlorine are also needed but in very small amounts.

Support. In a garden the plant roots are surrounded by soil that supports the growing plant. A hydroponically grown plant must be artificially supported, usually with string or stakes.

PROBLEMS OF GROWING PLANTS IN SPACE-

1) **Water**

The solution is simple, its simple osmosis. Two fluids are in a bag. One is sugar solution, highly concentrated, and the other is human urine. Technically, the online NASA demonstration stated that it was 'dirty water'. The membrane between the two bags allows the water molecules, and only the water molecules, to get drawn through, lured by the high concentration of sugar molecules on one side and the relatively low concentration of salt on the other. Next, enzymes in a bioreactor convert the leftover urea into ammonia, which feeds into an electrochemical cell that uses the ammonia to generate electricity."

2) **O2 ANDCO2**

So we do not have to worry about how oxygen would be provided to the plants but what about carbon dioxide.

Simple, we produce carbon dioxide in our bodies when our cells break down food and we release it when we exhale. In the atmosphere, carbon dioxide concentrations are approximately 0.04 percent. However, in the confined cabins of spacecraft, like the space shuttle or space stations, the carbon dioxide concentration can get much higher, which poses a problem because carbon dioxide is toxic. On Earth, plants remove carbon dioxide through the process of photosynthesis. The plants take in carbon dioxide and release oxygen. However, in a spacecraft, carbon dioxide must be removed from the cabin air through chemical processes. So, what I thought was that we could simply provide an inlet in the air ventilators to the plantation chambers. The carbon dioxide released could be taken to the gas chambers and could be used efficiently to produce more ureaponic systems. Moreover, the plants would also provide oxygen for the humans.

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Another thing to be noted is that CO2 and O2 would only be for the initiation of the respiratory and photosynthetic processes. Once the processes start plants would take their products and use them themselves efficiently much like they do it on earth.

3) **Light**

For the process of photosynthesis light is another aspect to be taken into consideration. And an easy alternative is providing artificial light to the plants by installing LED lights which are very efficient. High intensity lamps such as high-pressure sodium lamps can provide more than 1,000 foot-candles of light. Further they even long lasting as compared to the yesteryears Bulbs and Tube lights. Also, they would help harmonies of plants stimulate and would provide them direction to grow. This would diminish the problems of roots going circular in space due to absence of light as experimented and reported by the NASA scientists.

4) **Minerals**

Green plants must absorb certain minerals through their roots to survive. In the garden these minerals are supplied by the soil and by the addition of fertilizers such as manure, compost, and fertilizer salts. In space we will provide the necessary minerals by adding necessary amounts of synthetic urea. More than 90% of world industrial production of urea is destined for use as a nitrogen-release fertilizer. Urea has the highest nitrogen content of all solid nitrogenous fertilizers in common use.

HYDROPONICS

Hydroponics is a subset of hydro culture and is a method of growing plants using mineral nutrient solutions, in water, without soil. Seen as the most simplistic hydroponic system, The Wick system, is described as a passive system, by which we mean there are no moving parts. From the bottom reservoir, your specific Growth Technology nutrient solution is drawn up through a number of wicks into the growing medium. This system can use a variety of mediums, perlite, soil or coco.The roots of the plant are totally immersed in the water, which contains the specific Growth Technology nutrient solutions. An air pump with help oxygenate the water and allow the roots to breathe.

AEROPONICS

NASA-sponsored plant experiments prove that you don't need soil and lots of water to grow plants. These plants have developed healthy root systems, all while growing in a no-soil environment. Plants have been to space since 1960, but NASA's plant growth experiments began in earnest during the 1990s. Experiments aboard the space shuttle and International Space Station have exposed plants to the effects of microgravity. These experiments use the principles of aeroponics: growing plants in an air/mist environment with no soil and very little water.

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In 1997, NASA-sponsored studies aboard the Mir space station studied adzuki bean seeds and seedlings, a high-protein Asian food crop. While the beans were growing in zero gravity, ground control experiments watched to see how another group of seeds and seedlings responded on Earth. Both sets of plants were treated with an all-natural, organically-derived, disease control liquid known as Organic Disease Control, or Organically Derived Colloidal (ODC). While all of the seeds did well, those aboard Mir grew more than those on Earth. Both sets of plants treated with the ODC method grew more robustly and exhibited less fungal infection than the untreated seeds and seedlings.

Results from NASA's research aboard Mir have contributed to rapid-growth systems now used on Earth. Plants are started from either cuttings or seeds, then suspended mid-air in a growing chamber. The developing root systems grow in an enclosed, air-based environment that is regularly misted with a fine, nutrient-rich spray. A grower clips the leaves of plants grown in the openings of an aeroponic chamber. Aeroponic growing systems provide clean, efficient, and rapid food production. Crops can be planted and harvested in the system year round without interruption, and without contamination from soil, pesticides, and residue. Since the growing environment is clean and sterile, it greatly reduces the chances of spreading plant disease and infection commonly found in soil and other growing media.

AQUAPONICS

Aquaponics, refers to any system that combines conventional aquaculture (raising aquatic animals such as snails, fish, crayfish or prawns in tanks) with hydroponics (cultivating plants in water) in a symbiotic environment. In normal aquaculture, excretions from the animals being raised can accumulate in the water, increasing toxicity. In an aquaponic system, water from an aquaculture system is fed to a hydroponic system where the by-products are broken down by nitrification bacteria into nitrates and nitrites, which are utilized by the plants as nutrients, and the water then recirculates back to the aquaculture system.As existing hydroponic and aquaculture farming techniques form the basis for all aquaponics systems, the size, complexity, and types of foods grown in an aquaponics system can vary as much as any system found in either distinct farming discipline.

UREAPONICS-

Pure hydroponics,aeroponics or aquaponics could not be performed in space due to the scarcity of water, minerals and availability of co2 and o2. Hence, I came up with a new process known as ureaponics that bases its principles on hydroponics,aeroponics and aquaponics. Ureaponics is about using human urine to breed plants in space. This not only can be used as a substitute of water but also provides us with minerals which can be beneficial for plant growth.

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Problems with ureaponics-

1)***Excessive Minerals***

When we talk about taking urine altogether as our nutrient solution we can also see that we are bound to encounter certain complications and one such is the excess of urea in urine. We know urea is good source of natural fertilizer for plants but excess of urea is harmful for plants according to previous studies. So the question arises is how do we tackle excessive urea in urine?

We could think of adding Ketosteril tablets in the urine solution and thus reduce the urea content.

Ketosteril is generally known as Compound α-Ketoacid Tablets and it is used for preventing and treating renal damages due to protein metabolism disorder in chronic kidney disease (CKD).

Ketosteril can supply amino acid and reduce the producing of urea and help lower the level of creatinine and urea nitrogen and at the same time improve the nutritional status.

However, it causes some side effects. It can supply patients enough essential amino acids and has an function of calcium-phosphorus binder. With the wrong dose of ketosteril tablet, patients are more likely to suffer metabolic disorder of amino acids and hypercalcemia caused by the deposition of excess calcium, both of which may lead to more severe complications.

This was one such problem of which I could not find any solution. I knew the fact that urine has a lot of impurities and adding Ketosteril tablets would increase the impurities adding calcium products in the solution. Although plants require a portion of calcium but in what amount and in which form is hard to comment.Further, we can not alter the products in the solution by extracting them out which may not lead to healthy breeding of plants in space.

2)***pH of the nutrient solution-***

Inappropriate pH can cause harmful effects hence a proper pH level must be maintained in our nutrient solution.

The Purifying Machine-

Keeping in mind both of the problems we thought of a purifying machine that would satisfy our need. The purifying machine consists of two chambers-

1) ***Forward Osmosis chamber*** – Two fluids are present in two different bags. One is sugar solution, highly concentrated, and the other is human urine. The membrane between the two bags allows the water molecules, and only the water molecules, to get drawn through, lured by the high concentration of sugar molecules on one side and the relatively low concentration of salt on the other. Next, enzymes in a bioreactor convert the leftover urea into ammonia, which feeds into an electrochemical cell that uses the ammonia to generate electricity."

2) ***The Nutrient Chamber***-The solution obtained from the forward osmosis chamber is taken into this chamber where the solution is mixed with sufficient amount of human urine and other required minerals in order to create balanced nutrient solution with appropriate pH. This final product is used tobreed plants.

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WORKING OF THE MODEL

1. First of all, the ducts of gas chamber provide oxygen and carbon dioxide to the plants. The oxygen pipe is connected to the main oxygen storage of the space station and the carbon dioxide pipe is connected to the air ventilators installed inside the space station.CO2 would be taken from the respiration of humans
2. Nutrient solution is obtained from the purifying machine and is finally pumped out to the plants with the help of the sprinklers above the purifying machine.
3. The LED attached above the sprinklers provides necessary light for the plants to photosynthesis and the Plain mirror is for reflection of light to intensify the light and efficiently utilize scattered light.
4. Once the solution is sprayed upon the plant the sponges on the roots of the plants soak the solution and the solution is efficiently provided to the plants making the amount of wastage of resources to be negligible.
5. Then once the respiration and the photosynthetic processes start the outlet pipe situated in the gas chamber only helps take out the excessive O2 and CO2 in the environment. This situated in the air ventilators which can provide necessary oxygen to the humans and can provide oxygen and carbon di oxide for establishing further ureaponic systems.
6. We do not need to provide O2 and CO2 over a long period. It is just mandatory for the initiation of the necessary processes to take place.

The pictures below show the experimental model that we made to process the method of Ureaponics: -

Figure 1. A model representing a Ureaponic System

Figure 2. A system that shows how the water will be supplied.

Figure 3 Total working of a Ureaponic system.

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