Growing Plants outside the Planet

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Abstract

We joined a satellite design contest. In the contest, we suggested a satellite which can satisfy astronauts' appetite by growing plants in space efficiently. We aim to improve astronauts' quality of life in space and decrease the inconvenience in space if we travel in space in the near future. However, to realize this project, we have to solve problems such as radiation and lack of air in space. Therefore we conducted an experiment on Earth which clarifies how the condition of the air affects the growth of plants. And then, through this research, we calculated the perfect conditions to protect plants from space. Using this result, we suggest "Growing Plants outside the Planet" at a satellite Design Contest.

1. Purpose

We need food even in space. Getting food in space is necessary but it is hard. No one has ever found the way to get fresh food in space. Now astronauts eat specially processed food called 'space food' which is made to enjoy them, but they cannot eat fresh food, so space food does not fully satisfy their desire to eat. To solve this problem, we have to be able to sustain the plant's life cycle so that astronauts have unlimited plant resources, fresh vegetable and fruits. We started thinking how to carry it out. However, it's hard to grow plants in space because there is no air and gravity there is week. In addition, plants in space have to be able to tolerate a large amount of radiation in space. These three factors which are peculiar to space have prevented us from inventing a plant growth model so far. As I mentioned, gravity has a great influence on plant growth and radiation harms their cells. It can also cause them to mutate. We examined the extent to which these factors affected plant's growth and tried to find the best condition for plants in space. If we completely understand the best condition to grow plants, our satellite will be more effective and meaningful.

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2. Method

We conducted an experiment. In this experiment, we found how white radish sprouts seeds can grow in low air pressure.

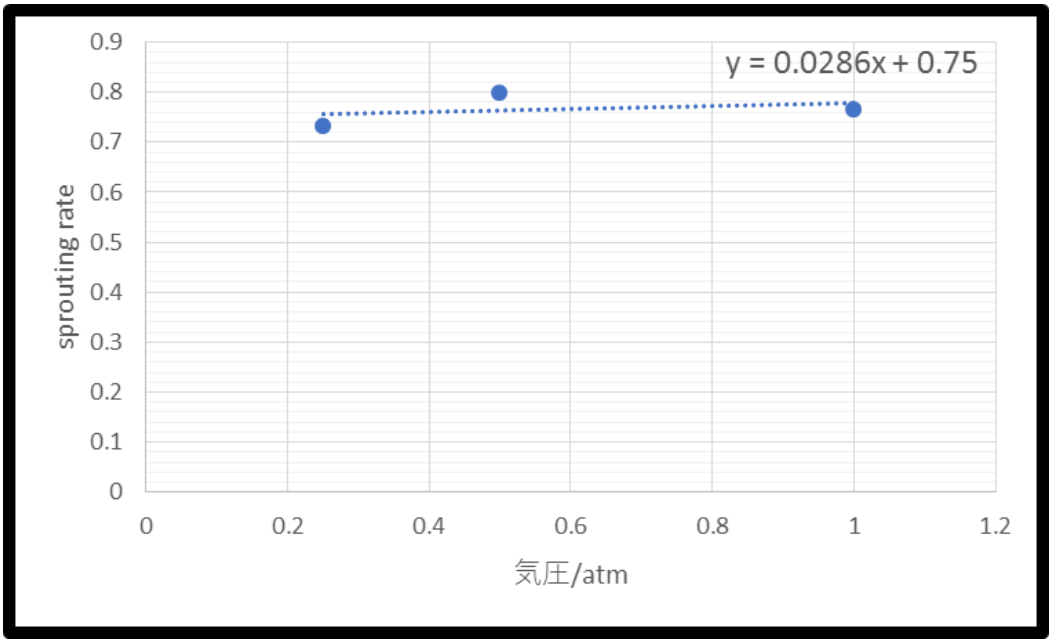
We will explain the method of this experiment. In the beginning, we make two slits on each sponge. The sponge's length is 110mm, the width is 65mm, and the thickness is 35mm. Then, we put 15 seeds in the slits. After that, we put sponges in water so that sponges are entirely filled with water. Afterward, we put two sponges into container and then inside a glass case. Then, we reduced the air pressure in the case and put the case in a place where the light source was about 280 Lux. The light source was a white LED light and was on between 8a.m. to 5p.m. We kept that condition for ten days and checked every 8a.m. and 5p.m. for the following three changes. First, we checked whether seeds have sprouted or not. Second, if they sprouted, we checked the height of each plant. Lastly, we check whether the air pressure has changed or not. If it has changed, we return air pressure to our original setting.

3. Hypothesis

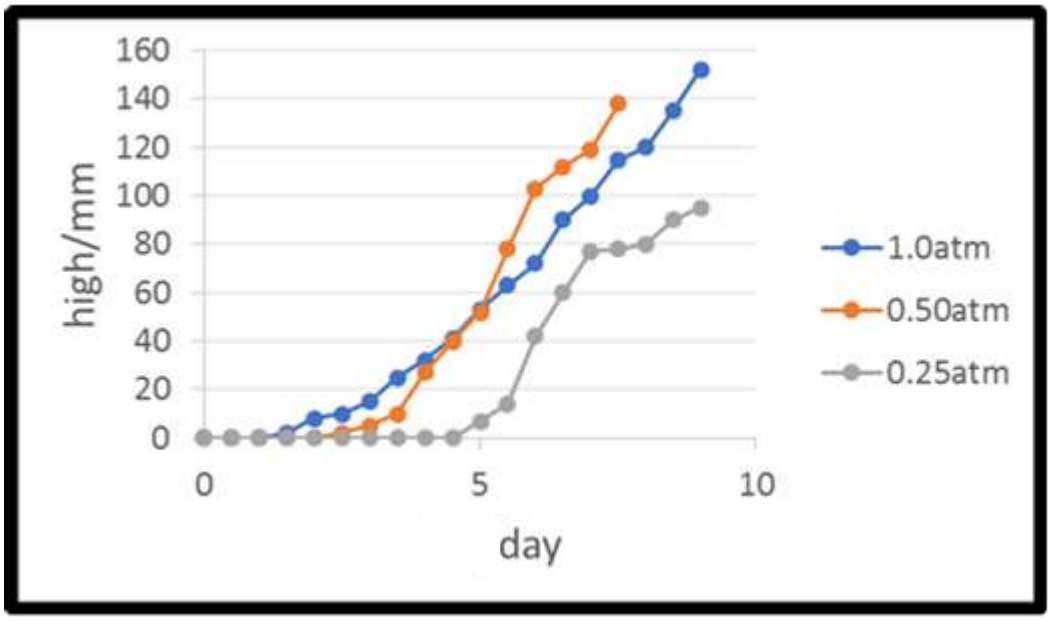
In our opinion, the weaker the atmospheric pressure, the slower the growth speeds becomes. It is because as the atmospheric pressure decrease, plants cannot absorb carbon dioxide. Then, plants cannot breathe enough. Therefore, we think if the atmospheric pressure become weaker than usual, plants' growth speed will become slow.

4. Result

Sprouting rate at 1.0atm was 0.767, 0.50atm was 0.800, and 0.25atm was 0.733. (graph1) In addition, the maximum height of plants in 1.0 Pa was 152mm, in 0.50 was 170mm, and in 0.25 Pa was 100mm. (graph2)



(graph1 the relationship between the air presure and the sprouting rate)



(graph2 growth speeds)

During the experiment, there were problems. For example, because we adopted the hydroponics using sponges, roots of the plants fell out from sponges and oil which appeared to be out of sponges. In addition, in this experiment, we adjusted the air pressure in the container only two times a day. However, at a lower air pressure such as 0.25atm, evaporation and transpiration of the plants was caused the are pressure to change.

4. Consideration

In this experiment, germination rates were almost same. However, they were lower than the standard in Gene bank in Tsukuba. Therefore, we need to identify the cause and improve the experimental method. The growth speed was faster for plants in this order, 0.50atm, 1.0atm, 0.25atm. However, we noticed that the difference was an error because there was a large variation. So, that air difference didn't have an influence on the growth rate, and we need experiments at lower atmospheric pressure than 0.25atm.

Also, we soaked the sponges in water before we grew the plants so that they would not float. However, that work is difficult to do in space. Therefore, we need to invent new system which enable astronauts to grow plants in sponges.

Moreover, it is difficult to prevente the roots of plants from falling out in space.

So, we need solve that problem, too.

5. Future outlook

We have to estimate the effect of radiation. This is the outline of the experiment.

1. Purpose

There is a large amount of radiation flying around the universe and it has had a big

impact on lives on this planet. Plants are also damaged by radiation, which collapse plants' DNA. So we imagined some possible experiments to evaluate damages of radiation.

2. Method

Calculate Energy

Using typical radical energy in space (about 100MeV), ionization loss is calculated. The answer was 14.7MeV/cm. The whole energy is computed by the following formula.

〔14.7MeV/cm〕×〔size of seed〕×〔the number of protons 〕MeV

＊we also considered the container

3. Hypothesis

If we expose seeds to more radiation, plants sprouting rate will decrease.

4. assignments

It is difficult to conduct an experiment because we don't have license to use radiation on earth so we will do that gradually.

In our experiments, we irradiated radiation during a short period of time. However in reality plants will be exposed to radiation for two years. To get information precisely, we have to do that slowly.

Moreover, actuary, cosmic rays have many kinds of atomic nucleus like alpha ray or lithium. So, we have to consider not only total dose effect but also effect on genes of plants.

There are certainly a lot of problems to preserve seeds. One of these problems is deterioration of seeds. This accounts for lights, oxygen, water, and high temperature.
We think that a lead box can block lights and that we can cope with water and oxygen by making the box vacuum. To deal with temperature, we keep the temperature in the satellite.

In addition, we chose hydroponic culture to conduct experiment. However, in space, it is essential to grow big plants, which grow roots into the ground. Then, we have to raise those plants using soil. Therefore, we have to establish the way of growing plants using soil.

Moreover, we observed germination rate and growth speed at 0.25atm, and the figure was almost same. However, to improve the environment efficiently, we have to decrease more the air pressure, and understand the condition that influences plants' growth speed. Therefore, we have to conduct the experiment at less than 0.25atm.

Through these experiments, we are trying to make the satellite, Growing Plants outside the Planet, and improve astronauts' quality of life in space and improve comfort during space travel.

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７．Key words

space plant space food air pressure satellite