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16. Abstract The absence of the force of gravity has a negative effect on plant life. Plants grown on spacecraft have died prematurely. Tests are being made to discover whether or not electricity will compensate for the absence of gravitation. It was found that an onion under current is not subject to the force of gravity. Tremendous possibilities are opened up by these experiments.

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LIFE OF THE ONION NOT KNOWING UP FROM DOWN

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Man through tremendous effort has over come Earth's force of gravity and has entered outer space. But the final victory over gravitation is still far off. Its absence in the spacecraft has many unfavorable effects on man and even more permanently his satellite and provider -- green vegetation. While man has learned to live and work in spacecraft for many months, the life of vegetation there is still counted in days. The causes for this are still unclear. /9*

The cosmonauts have taken a green friend with them more than once. On the Salyut-4 the Oasis was set up in which peas were grown. On the Salyut-6 there were containers -- vessels with onions which were grown with artificial illumination. Other plants were taken into space. But the results were all the same -- by the second or third week they were dead. One can imagine the mood of the cosmonauts when their green providers wasted away before their eyes!

"We were pleased to work with plants," recalls twice Hero of the Soviet Union, pilot-cosmonaut of the USSR, Pyetr Il'ich Klimuk in his notes. "One glance at them and our spirits rose..." and suddenly the plants die.

But there is more than a psychological aspect. Green plants are a necessary link in the closed system of life supply in space. It is just these plants which must supply the cosmonauts with fresh foods rich in vitamins, generate oxygen, absorb carbon dioxide, etc. Learning to grow plants in weightlessness is very important right now and without it one cannot successfully set up prolonged active stations or interplanetary flights. The problem disturbs many and one must hope that it will be solved.

Why are plants so bound to gravitation that they cannot live

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* Numbers in the margin indicate pagination in the foreign text.

without it? This involves the fact that during a long history and conditions of life on Earth, plants have developed their own vestibular apparatus. It seems to operate in approximately the following way: relatively heavy starch grains, floating in cells, under the effect of the force of gravity collect on one side or another and stimulate the cytoplasm of the cells. The growth hormones are directed toward the flexible part of the stalk and cause here active growth of tissue flattening out the bend. Thus, a plant orients its growth in space.

Many physiological processes are involved with this. It has been established, by the way, that the origin of the force of gravity is not so important to a plant. In the past century, botanists have grown different cultures in centrifuges. The plants have extended themselves precisely along the arrow of the vector which adds up to the effect of the force of Earth's gravity and the centrifugal force. The capability of the plant organs to take on a certain position due to the effect of Earth's gravity has been called "geotropism" (geo -- Earth, tropos -- rotation, direction).

And what happens when gravity is absent; the small stalks extend chaotically on different sides, not finding the required direction and after two to three weeks die. This phenomenon can be observed on Earth when growing plants in a clinostat. This setup does not create weightlessness but gives a similar effect. The outstanding specialist in the field of botany, academician of the Academy of Sciences of the Lithnanian SSR, Al'fonsas Ionovich Merkis considers that "the force of gravity, apparently, is necessary to plants. Which abnormalities are caused by weightlessness in the course of their development is unfortunately, still not clear."

What would help plants overcome the absence of gravity? It is completely logical to answer -- create an artificial gravitational field. Possibly in the future we will take this approach but right now it is practically impossible. And what if we call on electricity for assistance? The wellknown English physicist and theoretician R. Feinman writes that electrical force "like the force of gravity

is changed inversely to the square of distance but it is a million billion billion billions times more powerful"

Yes, electrical force is tremendous. It plays an important role in the life of everything living on Earth. The magnetic field rotating along with Earth is a gigantic battery with a negative pole at the surface of Earth, continuously emitting an electron flux into the atmosphere. This flux goes upward from the tops of leaves and stalks of grass and other vegetation. This process is not without differences for plants and it cannot have an effect on the work of their ion transport, that is, on supplying elements of nutrition and water. It has been established absolutely precisely that between the soil and the plant there is always a difference in potentials.

In the soil, a natural electrical field forms and the difference in natural potentials involves a number of soil characteristics. In soil rich with humus, the charge is larger than in soil with a small supply of organic substances (in the former, moreover, it is higher and richer). Natural electrical fields affect the processes of shifting of substances in the soil and, consequently, nutrition of the plants. With weak currents, bacteria multiply more rapidly.

Electrical energy occurs in the plants themselves. The constant difference in potentials is found between any living cells of animal and plant origin and their ambient atmosphere. Electroosmotic pressure, electrophysiological absorption of substances by cells and, finally, bioelectopotentials play an important role. In tests in the department of physiology of plants at the Timiryasev agricultural academy, conducted under the direction of professor N.I. Gunar, when leaves were cut from beans, for example, the bioelectrical response was recorded in the form of a sharp flash in the potential in a negative direction. Similar current effects occur during chemical, light, temperature and mechanical stimulation of the plants. It is considered that they play a role in different systems of signalization -- thus, the damaged root informs the stalk of its misfortune. With this assistance, the plant mobilizes its forces for restoring damage or lost health.

In weightlessness, these methods of interaction developed over thousands of years break down and possibly everything begins once more with electricity. It is fully probable that the difference of potentials in weightlessness between plants and the nutritive medium is much lower than on Earth and the constant flow of electrons from the roots to the tips of the leaves caused by rotation along with Earth's magnetic field is completely absent. If this is not so, then the supply of food to the plant and the biological and physical chemical processes occurring in it are complicated. The plant captures the intrinsic electrical powers stored in the seeds only in the first days of its existence. On Earth this is adequate because later on secondary electrical forces are included in the work; but how is it in space? One should not eliminate the idea that lack of success in growing vegetation in weightlessness involves this.

This hypothesis was proved in a test on a clinostat on which, as was discovered earlier, a certain similarity to weightlessness exists. Two polyethylene containers with onions every two seconds change direction from normal (pointed upward) to the exact opposite (pointed downward). The plant was positioned in such conditions so that it could not successfully adapt to change in direction of the force of gravity. Naturally it could not adapt to constant changes in its /10
biological processes: here electrical impulses occur even with bending of the plant at 15 degrees and with all 180, even more often the biopotentials must be continuously hurled in every direction. Also motion of the ions and consequently the food supply, water supply of the onion and so forth is more difficult.

The onions were placed in a clinostat when they had roots of more than two centimeters. An electrical current from an ordinary small battery for a pocket flashlight was fed to one of these; the second remaining without voltage was the control. The level of voltage was constantly controlled by a millivoltmeter. Otherwise both plants grew in absolutely uniform conditions. The results of the experiment were as expected. Even at the end of the first days of operation of the clinostat, the shoots of the onion had begun to bend and by the

fourth day its points had begun to go toward different sides and their tips to curve. The onion which received voltage continued to grow as if in a garden. On the sixth day, the control plant at the points had begun to show constrictions and their tips had wilted. All of this indicated that it was near death. And the onion which was under current remained well proportioned, green and healthy.

In order to conclusively prove how current favorably affects the growth of onions when it is constantly changing it "Earth" and "sky," on the sixth day voltage was supplied to the control plant and removed from the other plant. The picture changed sharply. Now the wilted onion began to straighten up, and the dried tips of the points fell off. A week had not passed after the change in the situation when the vegetation had acquired a normal aspect. Here, the two points which were under voltage showed noticeable growth (the plus was connected to them). The plant deprived of the potential branched out and the tips of the blades curved over. By the eighteenth day it had essentially stopped growing.

The test conducted makes it possible to expect that the absence of the force of gravity can be compensated for by electricity. Of course, careful studies are necessary which would be accompanied by observation not only of the exterior characteristics of growth of plants. Nevertheless, what is in the test described with the small battery shows that the onion grows more slowly than in containers standing in a row on a table. Consequently, experiments with voltage of different values are necessary and whether or not it is better with interruptions and possibly with alternating direction of the current so that one provides transport to the leaves of the nutritive substances with both positive and negative charges. It is just this method which gives the best results during electrical improvement of soil.

Nevertheless, the results of the tests are one more confirmation of the favorable effect of electricity on the life of plants. Electrical cultivation is not new. At the end of the last century, electrical stimulation was used to accelerate growth of barley in the

Arctic by 37 percent. Later on, potatoes, carrots, celery and certain other crops under a current yielded a harvest of 37 -- 70 percent more than usual. Tests were made in very different climates -- from Finland to the south of France. With abundant moisture, the harvest yield of carrots was increased by 125 percent, peas by 75 percent, and the sugar content of beets was significantly improved. Fairly large similar results have been obtained in our country. For example, A.A. Grebovich and G.S. Khachatryan established that with electrical stimulation the harvest of tobacco was increased by one-third. The dependence between the level of nitrogen in the food supply of barley and the value of the bioelectrical potential established by the Czechoslovakian scientists L.S. Zenishcheva and Ya. Shpunar is very important. In their experiment, the value of the potential in the plants was decreased with an increase in the dose of nitrogen applied. Many years of practice show that with an increase in the quantity of nitrogen fertilizer applied to the soil, the young seedlings are better lodged. Isn't it possible there is a connection between these phenomenona. And if there is, then it is possible obviously that having applied a certain additional potential, the lodging of the plants is prevented. This promises a tremendous yield -- the harvest can be increased by one and a half to two times.

The results of the tests described above with the clinostat are proof of this hypothesis: under current the onion is not subject to the force of gravitation. The plant is lodged once more by its own force of gravity.

It is considered that with the passage of direct current through any animal, a limit of electromotive force in the opposite direction arises. In the animal cells it causes free ions and occurs throughout the entire cellular volume. Here large organic elements of cells can participate, most of which are bipolar and have a large constant electrical moment; this means it is capable of orienting itself in the direction of force lines. In a large organic compound within a cell there are the growth hormones which, as is convenient to consider, are the main active forces for directed bends in the plants.

This means that their behavior is changed when introducing electrical currents. We still do not know in what way this occurs but when it becomes clear possibly it will change our concept of the mechanism of growth regulation of plants. Undoubtedly, there is the possibility of interfering in the work of these mechanisms directing in the way the cultivator wishes.

The prospects for adopting electricity in the technology of cultivating plants does not cause any doubts. Right now the sphere of its application can be fairly broad. Good results are obtained when electrical energy is used during separation of soil; tests are being conducted on machines for combating the harmful effect of cotton wilt -- using electrodes through the vegetation and for electrical processing of soil. The tests show encouraging results with an electrical field, particularly when growing plants in covered ground.

However, the scientific studies on electrical cultivation and their practical use are delayed by the inadequate level of mechanization and automation of the production processes in agriculture, and low energy supply. But tremendous possibilities are open in the next years in our country for this thanks to successive accomplishment by agrarian politics of the party.