https://doi.org/10.15407/knit2021.04.065
UDC: 635-14

N. M. JAPASHOV[1,2], senior lecturer, Ph.D. in Phys. & Math.
E-mail: dzhapashov_n@hbalm.nis.edu.kz
A. A. MANSUROVA[1,3], Researcher, Ph.D. in Phys. & Math.
N. BALTA[4] ,Ph.D. in Phys. & Math., Professor
[1] Al-Farabi Kazakh National University, Almaty, Kazakhstan
Al-Farabi Ave. 71, Almaty, 050040, Kazakhstan
[2] Nazarbayev Intellectual School of Chemistry and Biology, Almaty, Kazakhstan
Elibaev Str 2, dist. Kalkaman 2, Almaty, 050006, Kazakhstan
[3] Nazarbayev Intellectual School of Physics and Mathematics, Almaty, Kazakhstan
Zhamakaev Str 145, Almaty, 050040, Kazakhstan
[4] Suleymen Demirel University, Almaty, Kazakhstan,
Abylai khan Str 1/1, Kaskelen city, Almaty region, 040900, Kazakhstan

CREATING A MICROGREEN GROWING ENVIRONMENT AT THE SPACE STATION

Plants are essential types of human nutrition, both in terrestrial and in space station conditions. The cultivation of plant foods in space conditions at the near-Earth stations has become possible due to the modern achievements in agricultural technologies. The proposed article aims to study the creation of optimal conditions for growing plants used in human nutrition in the space stations. In the work, a selection of plants and soil types for space station conditions was made. For this purpose, a three-stage experiment was carried out. In the first experiment, an experimental method was exploited to select the types of plants that are most suitable for growing under extreme conditions. The composition and structure of the soil were determined experimentally. It is shown that hydrogel can be used to accumulate water in space station conditions and can be a suitable medium for growing plants. Studies have shown that just hydrogel (without any nutrient mixtures) can promote plant growth. At the second stage of research, plants were successfully grown on the mixture of the hydrogel and the soil. In the third experiment, the authors added biostimulants and organic products to the hydrogel, and as a result, there was an increase in the speed and stability of plant growth. The experimental prototype of the container for growing plants in space conditions, which was tested in the above experiments, created by the authors, is shown.

Keyword: *microgreen, microgreen planting, hydrogel, planting microgreen in hydrogel, planting in space station.*

INTRODUCTION

Delivery of one full lunch per astronaut costs approximately $5000 [10, 19]. Moreover, it is limited in a volume that makes the process of delivery problematic. Due to this, one of the best solutions to this problem would be growing food on the space station. A person's daily diet should consist of micro and macro elements, vitamins, and other nutrients. The richest source of such substances is plant-based organic food, so we decided to find a way to grow plants on the space station with minimal cost and maximum benefit.

However, even under Earth conditions, growing indoor plants is fraught with some difficulties. To grow a full-fledged plant requires prepared soil, adequate lighting, and proper watering. However, it is water that is the main factor in the cultivation of the plant since its deficiency, as well as excess, leads to the death of a plant. In the absence of gravity, water loses fluidity and scatters in droplets throughout the station, which is detrimental to machinery and equipment. To avoid this problem, we suggest using a polymer material — hydrogel [20]. Its feature and the main advantage is the ability to absorb and retain

Цитування*:* Japashov N. M., Mansurova A. A., Balta N. Creating a microgreen growing environment at the space station. *Space Science and Technology*. 2021. **27**, № 4 (131). С. 65—73. https://doi.org/10.15407/knit2021.04.065

moisture, as well as to give it in the right amount to a plant, which helps to maintain a sufficient amount of moisture in the soil.

The idea of ensuring the livelihoods of people in long-distance space expeditions with the help of vegetating plants was developed at the beginning of the last century by the founders of the Russian cosmonautics K.E. Tsiolkovsky and A.F. Zander [4] and continues to be relevant today. With the advent of the Salut space station [15], Mir space station [18], and International space stations [12, 13], its development received a new impetus. On board orbital stations, experiments with plants began to be carried out systematically.

Since 2004, the United States, Russia, and several other space powers have announced their intentions to carry out an expedition to Mars in the near future. Thus, experts from many countries have moved from developing concepts for preparing long- term space missions and permanent planetary bases to solving specific technical problems and developing optimal conditions for growing various plant varieties. A lot of effort is directed, in particular, to the creation of the Bioregenerative Life Support System (BLSS), the main and integral part of which is the link of higher plants. Plants in the BLSS can perform functions such as improving the crew's diet and atmospheric regeneration. To date, dozens of samples of vegetation equipment used for research purposes have been developed and successfully tested in space [2]. Numerous experiments on growing plants in space flight allowed us to formulate a set of requirements for the habitat of plants in space greenhouses. Almost all currently known designs of organic matter were created not only to ensure high productivity of edible biomass and to contribute to the diet of astronauts but also to conduct scientific experiments with plants in a well-controlled environment in space flight conditions. Meanwhile, a number of additional requirements are imposed on the space greenhouses intended for the production of plant foods in BLSS. The production space greenhouses onboard the manned spacecraft must be constantly in working order, therefore, they must meet the stringent restrictions imposed on any subsystem of the BLSS. At the present stage, in preparation for long interplanetary expeditions, the task of optimizing plant growing conditions has become urgent to obtain the required yield of useful biomass with minimum consumption of space station onboard resources. Since the ISS is currently the only long-term manned spacecraft, the implementation of these productive plant cultivation methods for the crew's life support system should be carried out primarily on it. However, before the flight tests, a large amount of ground research has to be performed.

Considering the ways of saving such resources as volume and energy, the developers of the space greenhouse quite a long time ago came up with the idea of growing plantings in clay-based containers [3, 9]. This container was named Veggie. By using this apparatus, a group of astronauts first tried lettuce leaves at the 5th week of cultivation, grown under zero gravity [11]. According to NASA, there is no difference in nutritional value between the lab's last "crop" and vegetables grown under normal conditions [17]. In contrast, the authors of the work [22] claim that a systematic analysis of regulatory networks at the molecular level of higher plants is needed to understand the molecular signals in the distinct phases of the microgravity response and adaptation. Raymond M. Wheeler [21] did a review of related works and found out that novel technologies and findings have been used to grow plants in microgravity. This includes the first use of light-emitting diodes for growing crops, use of hydroponic approaches for subterranean crops like potato and sweet potato.

A number of scientific studies state that the growth of the stem and leaves are directed towards illumination, i.e., phototropism takes place [5]. It should be noted that gravity does not affect plant growth [6]. However, the work [8] states the idea that microgravity has a significant effect on cell metabolism, modifications are reflected in the metabolism of cell ultrastructure, and rearrangements occur within the framework of the ontogenetic program, which is determined genetically, that is, within the physiological response. Since in this work we did not carry out studies at the molecular level, we preferred to neglect the necessary gravitational effect, relying on the fact that the proportion of gravity impact is small in the process of growing plants [6].

RESULTS AND DISCUSSION

In this paper, we focus on growing microgreen plant on hydrogel-based soil in conditions of the space

Fig. 1. Plants in the hydrogel grown in an environment similar to that of the space station

station. It is no secret that astronauts have weakened immunity and a lack of minerals and vitamins, such as C, D, E, K. Eating green leaves, you can easily get the daily intake of vitamin C because it is found in almost all cultivated crops (from oats and wheat to radishes and broccoli). The same can be said about carotene, phosphorus, iron, magnesium, and calcium. As for vitamins, in each plant they will have a whole complex: in kohlrabi — vitamins A, C, E, K, in watercress — B, E, PP, D, and in pea sprouts — C, PP, E, K.

Hydrogel and its properties.A hydrogel is a water-absorbing polymer that is found in the form of powder or granules. When mixed with water, the gel swells and absorbs water. The absorption of the hydrogel varies depending on the area of application, but the average dose of the garden hydrogel is approximately equal to the ratio of 10 g of gel per 1 liter of water. In the dry state, the polymer chains of the hydrogel are in a "folded" state, and when added, they diverge, allowing water to penetrate, which causes the swelling to form a hydrogel [14]. A hydrogel has inert properties, that is, it is very difficult for it to enter into any chemical bonds with other substances at room temperature. It is non-toxic and also retains its properties for about five years, which makes it very convenient to use and store. When decomposed, it decomposes into carbon, oxygen, and nitrogen, which makes it environmentally friendly [14].

Hydrogel creates a comfortable environment for plant growth without saturating the roots with moisture. This is due to the difference in concentrations of water in the gel and in a plant. If a plant does not have enough water, then osmosis occurs from the hydrogel to the roots of the plant according to the concentration gradient. *Another advantage of the hydrogel is that* it can hold water longer *in itself* since the evaporation rate of moisture from the surface of the hydrogel is not too high.

According to the above said, we provided some experiments with growing plants in onboard conditions (with controlled temperature, pressure, humidity, etc.). Our main goal is to find suitable plant types and soil compositions for space station conditions.

First experiment. Comparison of different plant varieties. In the first step of our research, we cultivate different plants in the hydrogel base to select the most suitable plant varieties that can be grown on the space station. Both dicotyledonous seeds (peas, watercress, kohlrabi) and monocotyledonous seeds (wheat, spinach, oats) were used for the experiment. The solution, the concentration of which was 50 g of hydrogel per 5 liters of water, was poured into plastic cups (see Fig. 1). Seeds were placed in the containers with the hydrogel, which were covered with cling film and finally put in a dark and warm place at room temperature.

The general condition of the plants was assessed every three days by the color of sprouts, the growth rate, and the content of useful microelements. The registered data are presented in Table 1.

As follows from Table 1, the Ding's peas show the highest results in the growth rate and the stem length compared to other plants. Among monocotyledons, the wheat had the highest rate. In contrast to monocotyledons, dicotyledons have open-type vascular bundles of the same size arranged in the form of rings, and the formative tissue (cambium) develops

Table 1. **Length of sprouts of different plants grown in an environment similar to that of the space station, cm**

Plant name(In latin)	8 Jan.	11 Jan.	14 Jan.	17 Jan.	20 Jan.	23 Jan.	26 Jan.	29 Jan.	1 Feb.
Ding's Pea (Pisum)	4.6	5.4	6.5	7.3	8.12	8.9	9.8	11.4	13.1
Wheat (Triticum)	3.1	4.3	5.1	6.2	6.9	7.4	8.2	9.1	10
Watercress Salad (sisymbrium acetaria)	3.2	4.6	5.4	6.5	7.2	7.9	8.5	9.4	10.3
Spinach (Spinach)	2.3	2.7	3.2	3.8	4.4	4.9	5.4	6.1	6.9
Kohlrabi (kohlrabi)	2.9	3.8	4.6	5.4	6.5	7.2	7.9	8.6	9.4
Oats (avena)	1.9	2.5	2.9	3.4	3.9	4.4	5.1	5.8	6.5

between the wood and the bast, which provides a secondary thickening of the plant walls.

Second experiment. Comparison of the effectiveness of hydrogel and soil. To select the optimal soil conditions for seed germination , we conducted the next experiment by planting the same seeds in three types of substrate: black soil, hydrogel, and black soil mixed with hydrogel.

Consequently, we placed each substrate in 200-gram plastic containers and sowed the same amount of pea seeds in them. To provide the plant with water, the hydrogel was dissolved in water in the proportion of 10 grams of hydrogel per 1 liter of water, and during the experiment, the plants on the hydrogel base or the mixture of the black soil with hydrogel were not supplied with additional watering. Only the black soil was watered in the proportion of 200 g of soil per 35 ml of water every week.

The experiment started on December 18, 2018. Control values of the length of sprout were taken three times at intervals of two weeks. The results of the measurements are presented in Table 2, and supporting images are shown in Fig. 2 and Fig. 3.

As follows from Table 2, hydrogel showed the highest germination rate of pea seeds. However, after 1.5 months, the plant died. The plant in the soil showed the slowest germination rate and required regular irrigation of the soil. The mixture of the soil and hydrogel showed an average seed germination rate and did not require regular watering.

Table 2. **Lengths of sprouts of peas for different media grown in an environment similar to that of the space station, cm**

Date	Soil	Hydrogel	Hydrogel mixed with soil
30.12.2018	5	8	6
07.01.2019	5.7	9.5	5.7
14.01.2019	6.5	11.6	7.8
25.01.2019	7.6	12	9
31.01.2019	8.4	13.2	10.2
07.02.2019	10	Died	12

Third experiment. Microgreen plant growth culture and medium.The next experiment was to reveal the necessary conditions for quick and sustainable growth of plants, namely, the composition of the nutrient medium. For this purpose, we have added the bio-stimulants and organic products to the hydrogel.

For one of the samples, we used the hydrogel + heteroauxin complex as a base. It contains a mixture of polysaccharides aggres and agaropectin (agar), hydrogel, distilled water. The heteroauxin is a plant hormone that accelerates the growth and formation of rhizomes. The benefits of using this bio-stimulant are that, penetrating into plant tissue, it irritates them and stimulates cell division. Subsequently, they transform into healthy roots.

For the other plant samples, we created organic nutrient soil. The composition of the nutrient mixture with organic products includes banana, activated carbon, powdered hydrogel, sugar, and distilled water.

The advantages of using banana pulp over mineral fertilizers are that the product contains virtually no chemicals. The banana pulp comprises potassium, phosphorus, calcium, magnesium, and nitrogen. Trace elements are needed for abundant flowering, the growth, and the development of indoor plants. Seedlings of vegetables when using banana top dressing grow faster. Sometimes microgreens are defenseless against fungi and infections, so we used activated charcoal to protect them from diseases. Coal is also an excellent alternative to blood-forming drugs because, thanks to it, cuttings take root faster and bet-

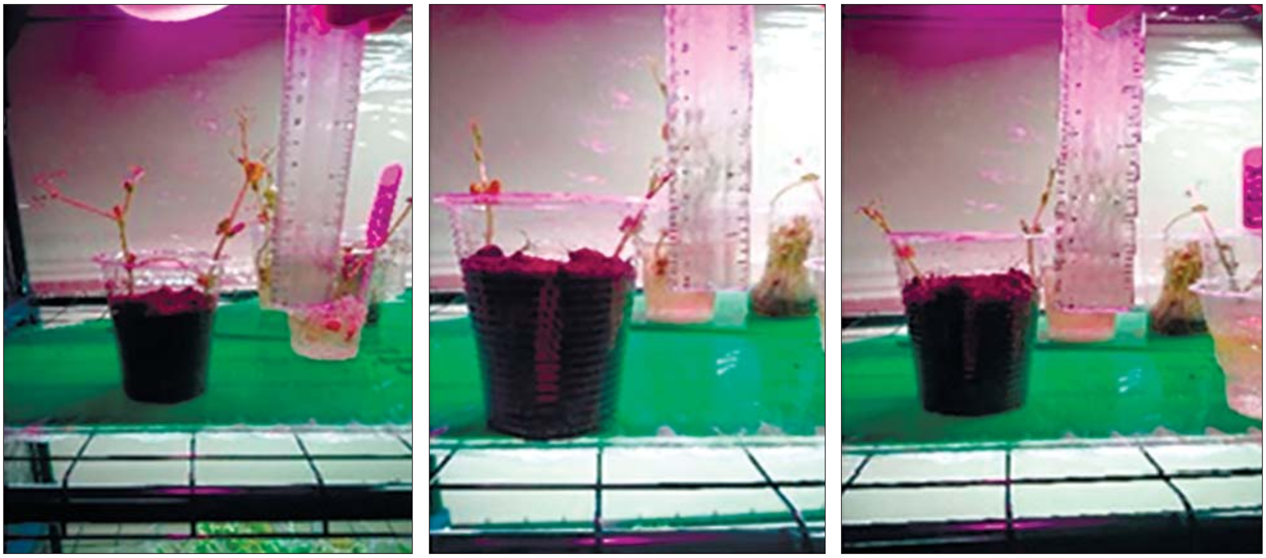

Fig. 2. Peas in the soil grown in an environment similar to that of the space station

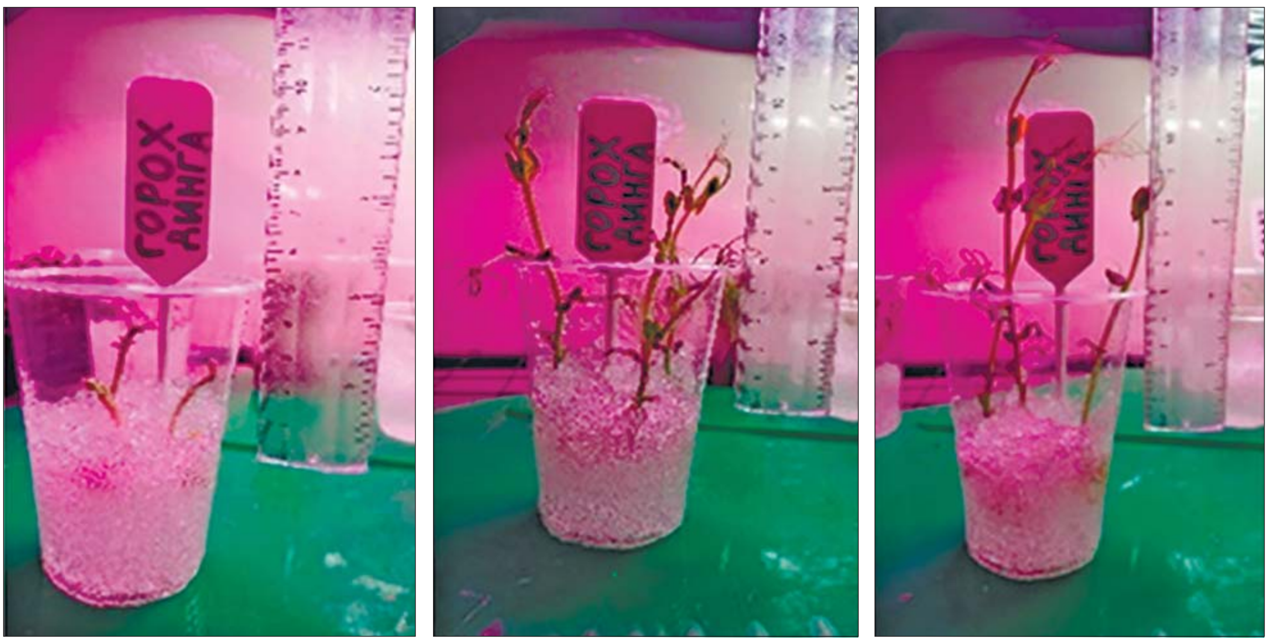

Fig. 3. Peas in the hydrogel grown in an environment similar to that of the space station

ter. Besides, coal absorbs moisture perfectly and prevents pathogenic microflora from multiplying. To compensate for the lack of ultraviolet rays in plants, we decided to add sugar.

Back in the 19th century, the world-famous scientist Michurin introduced sugar directly into the tissues of green experimental plants. Other experimenters successfully cultivated green spaces, including ferns and algae, generally without exposure to sunlight, only due to fertilizer with sugar. Thus, it was proved that it is a sweet solution that is able to compensate for the lack of light in a certain way. It is be-

Fig. 4. Container for growing plants in the space station conditions

Table 3. **The average value of plant growth per month in the nutrient medium in an environment similar to that of the space station, cm**

Types of Micro greens (In Latin)	Hydrogel	Hydrogel + hormone	Hydrogel + Nutrient Mixture
Amaranth (Amaranthi)	7.2	9.4	9.42
Kohlrabi (Kohlrabi)	6.5	7.8	7.83
Watercress (sisymbrium acetaria)	7.5	8.4	8.6
Spinach (Spinach)	5.4	6.7	6.9
Wheat (Triticum)	6.9	7.8	7.9

lieved that sugar is most important for feeding flowers in winter since the sun is not frequent at this time and plants lack ultraviolet light.

Table 3 shows the average value of plant growth per month. As seen from Table 3, the nutrient medium that we created is better than the environment with hormones, and unlike hormones, our nutrient mixture does not contain harmful chemicals at all.

Container for growing microgreen plants in the space station environment. As a part of this research, we constructed a container for growing plants. The container is made in the form of a hexagonal prism and is an independent unit in a cellular system of similar cells (Fig. 4). The material used to create the ribs of our installation is polytetrafluoroethylene (fluoroplast). The main advantages of the material used for the container are the next: high resistance to UV rays, mechanical strength, a wide range of operating temperatures from –269 to +26 °C, almost unchanged by temperature changes, it is a very hydrophobic substance, physiologically and biologically harmless.

The container is equipped with a device for monitoring the state of plants, namely a temperature sensor with the scale in degrees Celsius. There is also a photoresistor to control the illumination of plants. To prevent the accumulation of excess moisture, a fan is used located on the cover of the unit. This allows outside air to pass inward and vice versa.

The results of the first experiment indicated that hydrogel actively promotes seed germination, as it provides the optimal amount of moisture required for the process. However, the hydrogel alone does not contain nutrients, and this causes the death of the plant. The solution was to add hormones and nutrient mixture to hydrogel in further experiments. Experiments show that the hydrogel is the easiest to use on the space station as a basis of the soil for microgreens because it does not require additional irrigation, does not leave contaminants, which plays a significant role in growing plants in studied conditions. It is worth noting that in zero gravity conditions, the removal of contaminants is a problematic and time-consuming process. The black soil mixed with hydrogel was more successful in the further cultivation of the plant. It also did not require frequent watering but left pollution. The plant sprouted well because after the nutrients in the seed ran out, the plant began to receive nutrients from the black soil, which cannot be said for the hydrogel. Soil without additives showed the lowest rate of growth but sufficient productivity.

Results of the first experiment indicate that dicotyledonous plants have a higher germination rate, especially pea seeds. Wheat also had a strong performance and was only slightly inferior to peas. Based on previous studies of microgreen, it can be argued that peas in the microgreen phase are more beneficial for the human body than in a phase of a full-fledged plant. On top of that, taking into account the onboard conditions, peas, watercress, kohlrabi, wheat are the most useful sources of nutrients for astronauts who have a lack of micro and macro elements in their organisms.

There are two possible risks for our container, namely, mold and damage [16]. The International Space Station is a hermetically sealed object with an artificial habitat. In this regard, at the station, there was an acute problem of the spread of mold and other harmful microorganisms, which led to the breakdown of technical equipment. It develops in a humid environment, and it can likely develop in a hydrogel. To avoid this problem the space station is usually equipped with ventilation devices. The principle of operation of the device lies in effect on living cells of a constant electric field with rapidly changing polarity. Such an effect leads to the appearance of pores in the cell membrane and then the death of bacteria and microscopic fungi. Protein remnants of cells are filtered and destroyed so as not to become food for other unwanted microorganisms. Therefore, mold does not pose a threat to growing plants and space station equipment. The second threat is minced due to the properties of the material the capsule is made of. Since the installation is made of durable fluoroplastic material, the capsule will not be damaged , even being hit hard. Due to zero gravity, the hydrogel containers can scatter in different directions inside the capsule. However, the hydrogel containers cannot leave the capsule. With immediate intervention, the plants will survive, but transplantation to another container will be required.

CONCLUSION

To confirm our proposal for growing plants on the space station, we have studied various sources of information [1, 7]. We found that using a hydrogel instead of soil is the best method for growing a plant because it does not need constant watering, it is effective in terms of yield, it does not cause pollution (for example, soil and clay leave dirt), it is safe to use, it does not need hermetically sealed packaging, as the gel will not break out and fly apart in zero gravity, it does not cause inconvenience when transporting a hydrogel from Earth to a space station, as it is delivered in dry form (powder), which is not damaged during the flight, it has a relatively low price (economical), and it does not require special skills or knowledge for successful planting.

Our experiments showed that Ding's peas had the highest yield productivity. This type of plant had the highest success of the shoot, tested under different conditions; moreover, it turned out to be immune to sharp or smooth changes in environmental conditions, nutritious and healthy, and easy to grow and care for.

Based on a number of scientific works and our own experience, we have chosen the most nutritious phase of plant growth, sufficient for consumption in food-microgreens, or seedlings. They are the most useful and at the same time the most economical for growing and further consumption. At the same time, they take a rather short time for germination, which allows you to plant a new batch of plants immediately after consumption.

Thus, our work allows us to draw a reasonable conclusion that we were able to create optimal conditions for the cultivation of nutritious plants at the space station, using the installation, soil substitute, and the most favorable plant variety. Although the work still needs improvement and more complex comprehensive research, this is a kind of prerequisite for researchers working in a similar field of science and technology. Nevertheless, we tried to bring our conditions for growing microgreens closer to those in the space station and came up with research conclusions. We recommend that plants, such as Ding's peas, can be taken for further research. It is the most resistant to extreme conditions and a highly vitamin-rich product that is able to support the daily human diet.

ACKNOWLEDGEMENT

Authors express their gratitude to N. Siesek, A. Makasheva and G. Beisenbaeva at Nazarbayev Intellectual School of Chemistry and Biology, Almaty, Kazakhstan, for their contribution to this project.

REFERENCES

1. Ahmed E. M. (2015). Hydrogel: Preparation, characterization, and applications: A review. *Adv. Res.,* **6**, № 2, 105—121.
2. Berkovich Y. A., Krivobok N. M., Sinyak Y. Y., Smolyanina S. O., Grigoriev Y. I., Romanov S. Y., Guissenberg A. S. (2004). Developing a vitamin greenhouse for the life support system of the international space station and for future interplanetary missions. *Adv. Space Res.*, **34**, № 7, 1552—1557.
3. Dutcher F. R., Hess E. L., Halstead T. W. (1994). Progress in plant research in space. *Adv. Space Res.*, **14**, № 8, 159—171.
4. Erohin A. N. (2006). *Optimizacia sistemi osveshenia rastenii dlia konveiernoi cilindricheskoi salatnoi oranjerei kak komponenta SJO pilotiruemogo kosmicheskogo korablia*: Autoref. kand. diss. Moscow
5. Hangarter R. P. (1997). Gravity, light and plant form. *Plant, cell & environment*, **20**, № 6, 796—800.
6. Hoson T., Kamisaka S., Masuda Y., Yamashita M (1992). Changes in plant growth processes under microgravity conditions simulated by a three-dimensional clinostat. *The botanical magazine= Shokubutsu-gaku-zasshi*, **105**, № 1, 53—70.
7. Kazemi F., Mohorko R. (2017). Review on the roles and effects of growing media on plant performance in green roofs in world climates. *Urban Forestry & Urban Greening*, **23**, 13—26.
8. Kordyum E. L. (1997). Biology of plant cells in microgravity and under clinostating. *Int. Rev. Cytol.*, **171**, 1—78.
9. Lai Y. H. A., Howe A. S. (2003). A kit-of-parts approach to pressure vessels for planetary surface construction. *AIAA Space 2003 Conference & Exposition*, P. 6281.
10. Mammarella M., Vernicari P. M., Paissoni C. A., Viola N. (2019). How the Lunar Space Tug can support the cislunar station. *Acta astronaut*, **154**, 181—194.
11. Massa G. D., Dufour N. F., Carver J. A., Hummerick M. E., Wheeler R. M., Morrow R. C., Smith T. M. (2017). VEG-01: Veggie hardware validation testing on the International Space Station. *Open Agriculture*, **2**, № 1, 33—41.
12. Massa G. D., Newsham G., Hummerick M. E., Morrow R. C., Wheeler R. M. (2017). Plant pillow preparation for the veggie plant growth system on the international space station. *Gravitational and Space Res.*, **5**, № 1.
13. Massa G. D., Wheeler R. M., Morrow R. C., Levine H. G. (2016). Growth chambers on the International Space Station for large plants. VIII International Symposium on Light in Horticulture 1134, 215——222.
14. Montesano F. F., Parente A., Santamaria P., Sannino A., Serio F. (2015). Biodegradable superabsorbent hydrogel increaseswater retention properties of growing media and plant growth. *Agriculture and agricultural science procedia*, **4**, 451—458.
15. Nelson M. (1997). Growing Super-Dwarf wheat in space station MIR. *Life Support & Biosphere Sci*, **4**, № 3-4, 155—166.
16. Novikova N., De Boever P., Poddubko S., Deshevaya E., Polikarpov N., Rakova N., ... , Mergeay M. (2006). Survey of environmental biocontamination on board the International Space Station. *Res. microbiology*, **157**, № 1, 5—12.
17. Prince R. P., Knott III W. M. (1989). CELSS breadboard project at the Kennedy Space Center.
18. Samsonov N. M., Bobe L. S., Gavrilov L. I., Novikov V. M., Farafonov N. S., Grigoriev J. I., ... , Sinjak J. E. (2000). Long-duration space mission regenerative life support. *Acta astronaut*, **47**, № 2-9, 129—138.
19. Seedhouse E. (2012). *The Birth of the World's First Commercial Astronaut Agency*. Astronauts for Hire. Boston, MA: Springer.
20. Singh A., Sharma P. K., Garg V. K., Garg G. (2010). Hydrogels: A review. *Int. J. Pharm Sci. Rev. Res.*, **4**, № 2, 016.
21. Wheeler R. M. (2017). Agriculture for space: people and places paving the way. *Open agriculture*, **2**, № 1, 14—32.
22. Zheng H. Q., Han F., Le J. (2015). Higher plants in space: microgravity perception, response, and adaptation. *Microgravity Sci. and Techn.*, **27**, № 6, 377—386.

Received 04.12.2019

Revised 20.04.2021

Н. М. Джапашов[1,2], старш. викладач, канд. фіз.-мат. наук
E-mail: dzhapashov_n@hbalm.nis.edu.kz
А. А. Мансурова[1,3], канд. фіз.-мат. наук
Н. Балта[4], проф., канд. фіз.-мат. наук
[1] Казахський національний університет імені аль-Фарабі
пр. аль-Фарабі 71, Алмати, Казахстан, 050040
[2] Назарбаєвська інтелектуальна школа хіміко-біологічного напрямку у м. Алмати
вул. Єлибаєва 2, мкр Калкаман 2, Алмати, Казахстан, 050006
[3] Назарбаєвська інтелектуальна школа фізико-математичного напрямку у м. Алмати
вул. Жамакаева 145. Алмати, Казахстан, 050040
[4] Університет імені Сулеймана Деміреля
вул. Абилай-хана 1/1. Каскелен, Алматинська область, Казахстан, 040900

СТВОРЕННЯ СЕРЕДОВИЩА ДЛЯ ВИРОЩУВАННЯ МИКРОЗЕЛЕНІ НА КОСМІЧНІЙ СТАНЦІЇ

Рослини є необхідними видами харчування людини як у земних, так і у космічних умовах. Вирощування рослинних продуктів харчування в космічних умовах на навколоземній станції стало можливим у зв'язку з сучасними досягненнями агротехнологій. Метою роботи є дослідження оптимальних умов для вирощування рослин, що використовуються в харчуванні людини на космічній станції. У роботі проведено вибір рослин і типів ґрунту для умов космічних станцій. З цією метою проведено триетапний експеримент. На першому етапі експерименту дослідним способом було здійснено вибір типів рослин, які найкраще підходять для вирощування в екстремальних умовах. Експериментальним способом було визначено склад і структуру ґрунту. Показано, що для акумуляції води в космічних умовах можна використовувати гідрогель. Дослідження показали, що тільки гідрогель може сприяти росту рослин. На другому етапі досліджень було успішно вирощено рослини на суміші гідрогелю і ґрунту. На третьому етапі експерименту у гідрогель були добавлені біостимулятори і органічні продукти, внаслідок чого збільшилась швидкість та стійкість росту рослин. У роботі описано створений авторами експериментальний прототип контейнера для вирощування рослин у космічних умовах, який було апробовано у названих експериментах.

Ключові слова: мікрозелень, вирощування мікрозелені, гідрогель, вирощування мікрозелені в гідрогелі, плантація в космічній станції.