SPACE FOUNDATION

THE SPACE REPORT

THE AUTHORITATIVE GUIDE TO GLOBAL SPACE ACTIVITY

2021 Q1

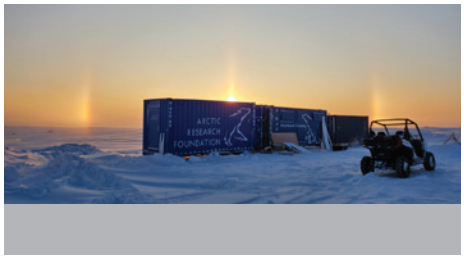
2020 LAUNCH ANALYSIS | U.S. SPACE WORKFORCE | ENHANCING GREEN GROWTH FROM SPACE TECH

Introduction | *The successful cultivation of plants is a necessary part of every human civilization. Space agencies for decades have recognized multiple advantages associated with growing plants to benefit astronauts on long-duration missions,[1] and by 2015, the first vegetables grown and eaten in space were cultivated on the International Space Station's Vegetable Production System (Veggie). Space technology research and development has led to the creation of innovative products that can enrich and improve life on Earth. Space science can also teach us a great deal about the cultivation of plants in harsh and unforgiving environments, providing potential food production sources for remote communities.*

Greens growing in the Veggie system onboard the ISS.
Credit: NASA

Naurvik Greenhouse in Nunavut

The Naurvik greenhouse, a community-led hydroponic system in Gjoa Haven, Nunavut, is an example of how plant-growth technology used in space is assisting people on Earth.[2] The cold and rocky environment of Gjoa Haven, located about 250 km north of the Arctic Circle, makes farming and importing fresh produce difficult and expensive.[3] To combat this supply issue, the local community, along with the Canadian Space Agency (CSA), the Arctic Research Foundation, Agriculture and Agri-Food Canada, and the National Research Council Canada, partnered to convert three recycled shipping containers into an almost entirely renewable energy-powered food production system.[4] Since 2019, local technicians have grown vegetables in the greenhouse year-round to deliver fresh food to community elders, schools, and workplaces.



External view of the Naurvik plant growth system.
Credit: Arctic Research Foundation

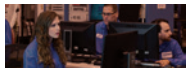
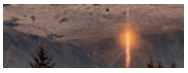
The Naurvik project benefits the Gjoa Haven community as well as CSA, according to Matthew Bamsey, a CSA senior engineer and project manager at the department of Astronauts, Life Sciences and Space Medicine.[5] CSA provides training in food production, safety, and renewable energy to the greenhouse technicians. Local residents are able to eat fresh, healthy food without additional shipping expenses driving up the costs. CSA, in turn, has the ability to test and research new plant growth technologies in the harsh climate of northern Canada that will assist astronauts in future missions.

First harvest at the Naurvik greenhouse
Credit: Arctic Research Foundation

Projects such as the Naurvik greenhouse are an important part of CSA's space strategy as it advances food production on and away from Earth.[6] Technicians hope to have the greenhouse running completely from renewable energy within the next few years. They also hope to help others in similar areas grow their own food by sharing their knowledge and experience. The success of the Naurvik partnership showcases how space science can be used to improve the lives of people every day and demonstrates the potential effect this technology could have on other remote communities or in skyscraper communities far removed from farmland.

Products Used on Earth

NASA has been partnering with private companies for decades to develop plant cultivation experiments for agency missions.[7] Gardening in space provides food and enjoyment for an astronaut crew, but can also filter waste products, dispense clean drinking water, reduce carbon dioxide and distribute fresh oxygen into the

air. Over time, space agencies have shifted from observational to food production research with over a dozen experiments launched into space since the 1960s.[8] The Vegetable Production (Veggie) System and the Advanced Plant Habitat (APH) are the latest systems onboard the International Space Station (ISS). So far, varieties of lettuce, dwarf wheat, and mustard have been grown on the ISS.

Several companies that have worked with NASA have adapted their products for professional and private use on Earth.

AeroGarden Indoor Gardening Systems

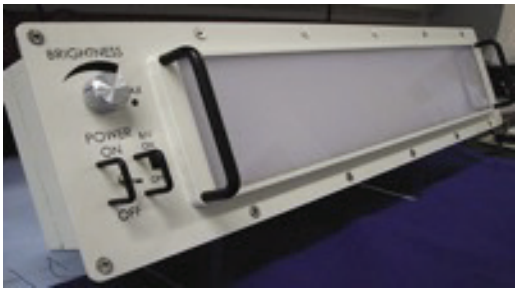
Aeroponics, or the method of growing plants suspended in air without soil, has many benefits for anyone attempting to yield a healthy crop.[9] Plants tend to grow more rapidly than with traditional gardening practices and can be harvested year-round. The requisite amounts of water and fertilizer are greatly reduced and, without soil, the need for pesticide control is eliminated. The fewer materials needed for aeroponic gardens make them well-suited for space missions. Not only do these systems weigh less to launch into space, they are also viable sources of oxygen and clean water.

NASA has worked with external agencies and companies for decades on several plant growth experiments.[10] The agency partnered with BioServe Space Technologies, a nonprofit, NASA-sponsored research center, to develop an aeroponic experiment that flew to the ISS in 2007. The plant seeds needed to be contained in a casing that could protect them on the flight aboard the Endeavor space shuttle and also prevent them from germinating before the experiment officially began. BioServe partnered with AeroGrow International, a company based in Boulder, Colorado, and used its Seed Pod technology to encompass the seeds in a plastic structure that would keep them secured during transport. Those first results, however, were returned to Earth for further study; consumption of ISS-grown produce didn't occur routinely until 2015.

AeroGrow's inventive products, however, proved good for more than just spaceflight. The company also sells AeroGarden indoor gardening systems for personal use.[11] AeroGardens include all the necessary materials and are designed to help anyone grow their own herbs, vegetables, and flowers right from their kitchen countertops, with no gardening experience required.[12] The company's 15 patents, which are all intended to make indoor gardening simpler and easier, include specialized lighting systems, nutrient tablets, and seed pods like those flown to the ISS.[13] Gardeners can expect plants cultivated in these indoor gardens to germinate quickly with little human involvement and produce continual harvests for up to six months.[14] These systems have become so popular that for the last nine months of 2020, the company reported net revenue of $69.1M, an increase of 151% vs. the same period last year,[15] a boost company officials acknowledge is due partly to the isolation prompted by the global pandemic. AeroGardens are available in various sizes and price ranges and can be purchased around the world in stores and online.[16]

Lighting Science LED Bulbs

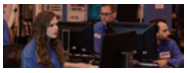
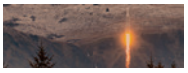
Just as aeroponic systems offer advantages over traditional gardening methods, LEDs, or light-emitting diodes, are also preferable to high-pressure sodium lamps. They not only last longer and require less power, but LED bulbs are also lightweight, shatter-resistant, and able to operate in extreme temperatures. They can also produce specific spectrums or colors of light without giving off heat. The LED bulb's light weight and adaptability make it perfect for use in space.



ISS LED lighting module.
Credit: NASA

The plant growth experiments on the ISS utilize LED bulbs as they can be modified to generate different wavelengths of light at various times depending on the specific type of plant and its current stage of development. Different light color combinations, or "light recipes," can have dramatic effects on plant size, shape, texture, and appearance.[17]

The Florida-based company Lighting Science has developed LED bulbs to help with lighting for indoor plant growth. The company even created bulbs for coastal regions that won't interfere with the migratory habits of marine life. These LED bulbs are long-lasting, with an average lifespan of 50,000

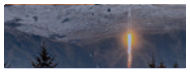



hours, and energy efficient. They cost less to operate than traditional high-pressure sodium lamps and don't give off excess heat, which can also reduce air conditioning expenses. Lighting Science, a NASA partner, holds more than 400 patents and continues to develop its lighting technology for consumers.[18]

Conclusion

The successful cultivation of crops will be a vital part of any future long duration spaceflight. With the limited capacity to launch supplies, astronauts must have the ability to generate their own food in order to survive far away from our home planet. However, this same technology has practical functions on Earth. The technology and materials developed for space can be used at the community level to benefit remote areas and at the individual level to improve the lives of people all over the world. These innovations highlight the importance and versatility of space science and demonstrate the far-reaching potential of these applications.

Tara Larson is a graduate of the University of Colorado with a master's degree in public administration with emphasis on the space industry. She is a contributing writer for The Space Report.

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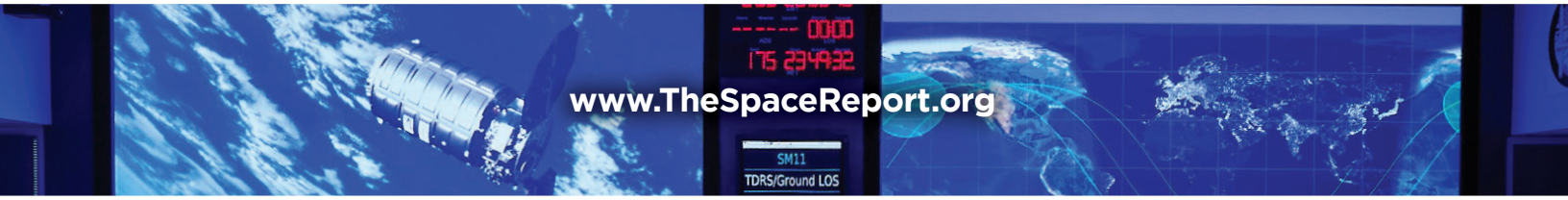

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Section 4 | Space Products & Innovation

Grow Technology Feeds Astronauts in Space, Creates Gardens in Unlikely Places on Earth

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