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HOW TO GROW FOOD IN SPACE

AT A REMOTE OUTPOST IN ANTARCTICA, SCIENTISTS ARE GROWING VEGETABLES

WORDS: **HAYLEY BENNETT** PHOTOGRAPHY: **ESTHER HORVATH**

Today's astronauts have to exist largely on pre-packed meals, with fresh fruit and veg being a rare treat. But indoor farming technologies are advancing, and the race is on to find effective ways to grow food in space – both for long-duration missions, and for future settlements on the Moon or Mars. So where's the best place to test these technologies? The bottom of the world, it turns out. At the Alfred Wegener Institute's Neumayer III station in Antarctica – a German base for polar research – scientists have created a standalone greenhouse as part of a project called EDEN ISS, which develops food production techniques for the International Space Station (ISS) and future human space colonies. Here, researchers are already seeing the fruits, or at least vegetables, of their labour.

FROZEN VEG

The frozen landscape of Antarctica might seem an unlikely place for a greenhouse, but the isolation, limited resources and harsh environment make it an ideal analogue of the conditions faced by astronauts growing crops in space. The 12-metre-long mobile facility – made from two interconnected shipping containers – houses soilless technology for indoor farming, including temperature and humidity control systems, water recycling, automated nutrient pumping, LED lighting and remote plant monitoring. It was kitted out in Germany and shipped to Antarctica in October 2017.

In this picture, EDEN ISS leader Dr Daniel Schubert (right) and a colleague drag a sledge loaded with supplies to the greenhouse facility, which is about 400 metres from the main Neumayer III station. It's "a pain in the ass" to get to in these conditions, Schubert says, explaining that the greenhouse is positioned this far away because of the huge snowhills that form behind any large object. The main station itself avoids this problem because it is specially shaped and raised on hydraulic stilts to prevent snow from accumulating.

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PUTTING DOWN ROOTS

The cultivation process at EDEN ISS is aeroponic – a soilless system where the crops absorb nutrients from a water mist applied at the roots. The vegetables are grown in vertical racks, giving a total growing area in the greenhouse of 12.5 square metres, with the roots exposed in plant growth trays.

Everything in the greenhouse can be regulated remotely from mission control at the German Aerospace Centre in Bremen, except, notes Schubert, seeding, harvesting and cleaning up – these have to be done by hand. Here, horticultural engineer Markus Dorn (right) prepares the seed trays using blocks of rock wool soaked in nutrient solution. Rock wool, which is made by spinning molten rock into fibre, has a candy floss-like texture that holds onto water and helps stabilise roots. The seeds will germinate in the seed trays for about two weeks before being transferred to the vertical racks.

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UNDER SURVEILLANCE

The greenhouse features a crop surveillance system: high-definition cameras that help the team keep tabs on the plant growth trays. In this image, plant scientist Dr Anna-Lisa Paul from the University of Florida is calibrating a specially adapted camera that is capable of detecting crop stress – in kohlrabi, in this case – even before it's visible to the eye. (The colour plate helps to make sure the colours are aligned between different images.) Healthy, unstressed plants that are well-hydrated and have all the right nutrients reflect a higher ratio of light in the 'near-infrared' part of the spectrum compared to shorter wavelength blue and green light. The camera is able to detect these wavelengths, determining whether the plants are stressed or healthy. Paul says that this means problems can be addressed before they become irrecoverable. "This is especially important when resources are limited, and the habitat is inherently challenging, such as in space," she says.

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REAP WHAT YOU SOW

Over the 2018 Antarctic winter, between February and November, the greenhouse produced 268 kilograms of crops, including 67 kilograms of cucumbers and 50 kilograms of tomatoes. The impressive harvest shown here was collected early the following year, in January 2019. In addition to cucumbers and tomatoes, the crew were treated to swiss chard, radishes, fresh herbs and different varieties of lettuce. The LED lighting is tuned to produce mostly red light, as this is the most effective colour for driving photosynthesis, but there are seven different light 'regimes' tailored to the height of the crops and the amount of light they need. "We've developed specific light mixtures for the plants," says Schubert. "So the lettuce, say, receives a different light mix than the cucumbers." The light also scales up slowly in the morning, creating an artificial dawn. Except for tomatoes, no fruit is grown here, but the crew have frozen fruit in their stores.


L1-2R
L2-1L
L2-2L
L1?-1S

NASA/JSC, GETTY IMAGES

FRESHLY CUT

With no hair salons for thousands of kilometres, station leader Dr Bernhard Gropp has taken up the clippers, giving electrical engineer Thomas Schad a haircut. Team bonding is important in these extreme conditions – in winter the temperature can fall below -40°C, and the polar night means that for 11 weeks of the year no sunlight touches the ice. As in space, a haircut and a few fresh greens might provide the crew with a boost in morale. The psychological impact of the fresh produce at Neumayer III is the subject of ongoing research. "We have a dedicated research team that's evaluating this with questionnaires and group discussions," says Schubert. "It seems like there is a positive effect." The EDEN ISS project is set to continue until at least 2021, with plant researchers worldwide being invited to propose studies for this unique facility.

SPLENDID ISOLATION

Every year, the Neumayer III research station, viewed here from the window of one of the Alfred Wegener Institute's helicopters, moves about 150 metres north, along with the Ekström ice shelf on which it sits. It's a lonely place, particularly during the nine-month winter, when nine crew members (three of whom share responsibility for the plants) spend the season completely detached from the outside world. During the summer, the number of scientists at Neumayer III swells to around 50, with multiple projects covering research topics ranging from air chemistry to marine ice to penguins.

Despite the isolation, there is close contact all year round between crew members in Antarctica and colleagues back in Germany. "Nowadays, it's quite easy," says Schubert. "We have a big WhatsApp group with the overwinterers, and a dedicated greenhouse chat group." But while the remote scientists can advise if something goes wrong, on-site technical expertise is crucial, just like in space. **SF**

DISCOVER MORE

BBC RADIO 4 *Listen to the president of the British Antarctic Survey Jane Francis tell Jim Al-Khalili about camping on the ice in Antarctica in this episode of* The Life Scientific ***bit.ly/jane_francis***

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