Farming in space

What are the challenges of astronomical agriculture?

Perhaps one commodity is needed above any other if humans are going to colonise the solar system: food. A robot does not need feeding – we do. The first human return trips to Mars will take a year, but it is hardly practical to take a year's worth of food along for the ride.

Or what if we're serious about staying longer, about building a permanent colony on the Moon or another planet? We're going to need to eat. You could send resupply ships from Earth to periodically restock the Mars colony but that's going to be expensive. And what if a mission fails? All these concerns mean that if we're ever going to have a permanent outpost on another planet it is likely we're going to need to grow our own food there. After all, many historians argue that the development of agriculture on Earth was one of the crucial achievements that kick-started modern civilisation. So it is likely to be in space.

First up, the diet is going to be vegetarian – space-based livestock is hardly the most practical option. The trouble with plants, however, is that they are so used to growing on Earth. In particular they have adapted to gravity, and Earth's specific strength of gravity at that. Experiments with plants have flown on space shuttles and space stations alike, but the outcome has been the same: plants don't like it when you take gravity away. It seems microgravity influences the biochemistry inside the plant cells, resulting in odd mutations or strange shapes. Radiation can mutate seeds and seedlings too.

Progress

However, in late 2014, a team of scientists from the University of Wisconsin reported successful growth of *Arabidopsis thaliana* – an edible, flowering plant – from seed on the International Space Station. What's more, they then used seeds from that plant to grow another while still in space. Other seeds were returned to Earth and germinated. In all, 92 per cent of the seeds from the first plant grew successfully. On the ISS the seeds were grown in very controlled conditions inside a capsule. Researchers had control over the temperature, humidity, carbon dioxide and the plant hormone ethylene.

So far, so good. But what about growing plants on Mars? This would have the added benefit of taking in some of Mars's thin atmosphere of carbon dioxide and providing us with oxygen to breathe. Yet Mars comes with a whole host of agricultural challenges. First, its gravity is 38 per cent of ours. Can lessons be learned from the ISS experiments about how to successfully grow plants in reduced gravity? Perhaps we could genetically engineer plants to thrive in such conditions.

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Another big limiting factor is light. Mars sits 1.5 times as far away from the Sun as we do. That means it receives less than half the sunlight we get on Earth. If plants can't be altered to accept the dimmer conditions, we would need to top up the amount of light to Earthly levels inside Martian greenhouses. That would require a significant amount of power – a great technological challenge on an alien world.

Then there are nutrients. Recent research has shown this might not be that big a problem. A study by a team of Dutch researchers has shown that tomato, wheat and cress can grow in simulated Martian soil for up to 50 days without any additional nutrients. However, the researchers do note that their simulated soil might not be an exact match for Mars. So if it turns out that you do need to add nutrients, where will they come from? Instead of taking them with you, some scientists believe you could mine them from nearby asteroids. Asteroids are the building blocks of planets and so contain many of the organic compounds found on Earth today.

The easiest way for us to get our hands on asteroids to test this idea is by using samples from meteorites, which have fallen to Earth from space. Researchers in New Zealand took some meteorites, ground them up and added water, then tried to grow plants in the mixture. It worked. They used their results to estimate that a 200-kilometre asteroid could provide enough of this makeshift fertiliser to sustain a human population of 10,000 for a billion years. Of course, these experiments were conducted on Earth, with our own particular gravity, so it is unclear whether the same thing would happen on Mars.

The only way to solve the problem is to keep pushing the boundaries of what is possible. More experiments mean more data and further insights into how to best grow plants in alien environments. A group of American high-school girls – who call themselves Chicks in Space – are currently trying to raise $15,000 to send their hydroponics experiment to the ISS. There is also an experiment in the pipeline that hopes to send a one-kilogram greenhouse to the lunar surface. Over ten days, video cameras will track the growth of turnips, cress and basil to see how they cope. Control experiments will be distributed to schools across the USA so students can help compare and contrast how the same plants grow on Earth.

It is all crucial work. After all, an astronaut needs to eat.

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