SISS_Space gardening

There is quite a lot of research being done on the ISS about plants. The experiments are not being undertaken to find a cure to all the woes of humankind – although, being science, who knows what we might find. In fact, all this research on plants is being done to support future space exploration. We are beginning to realize that we aren't going to get very far in space if we can't grow our own food once we're out there.

And it's not just about food. If the Solar System is anything to go by, we should find plenty of carbon dioxide and water throughout the galaxy, but we will hardly ever come across molecular oxygen, that is O_2. The O_2 that we are so familiar with on Earth is an ephemeral product of plants and other photosynthetic organisms. So, if we take plants with us into deep space, they can keep on turning the CO2 and water that's out there into oxygen, which we can keep on breathing. Those plants could also help to humidify our spacecrafts' air – and, of course, they can also be eaten afterwards. Indeed, the whole process becomes a bit of a virtuous cycle, since after we eat them we generate *(ahem)* fertiliser that will help to grow more plants that will then convert even more CO_2 and water… until they also get eaten.

So, there really are high hopes for a future space diaspora that will depend upon a close symbiosis between plants and humans. And it's not likely that those humans will be launching their dearly departed friends and family into the void via the photon torpedo tube. After all... *(sound byte)*

We have learnt from mad-cow disease that it is a very bad idea for a species to eat its own dead – you just create a new (and pretty-creepy) vector for disease transmission. So, don't worry, in the future Soylent Green won't be people, it will be an algal extract, perhaps supplemented by soybean proteins and a few artificial flavours. When our future space colonists die, they will be respected. Then they will be broken-down, irradiated and their remains used to supplement the algal growth medium – or maybe to supplement the soybean medium. You might even be able to make the choice, algae or soy, as an advance directive. Out there alone in deep space, depending on plants for the air we breathe and the food we eat, we *will* want to give something back.

But, for now, even ISS plant scientists have to come down to Earth if they want to secure their next funding grant, which means they need to build a business case that microgravity research can also identify new ways to increase crop productivity on Earth.

And that business case goes something like this. A fair proportion of a plant's solar energy uptake is usually expended on maintaining its stem and its other support structures – whose only real purpose is to counteract the effects of gravity. If you could switch off that energy diversion, with human intervention providing the needed support structures – perhaps in the form of reusable frames – then you could substantially increase the *yield* of those plants – that is the fruits, leaves, tubers… or whatever part of the plant represents its main commercial value.

It is kind of inevitable that humankind's current usage of arable land will become economically unviable in the future as our insatiable hunger for real estate drives us to grow crops inside compact, multi-storey greenhouses. So, we really do need to start doing research now towards developing genetically-modified plants, that don't waste energy in supporting their own weight and that are also specialised to grow in artificial environments.

Of course, making this happen will depend on us getting over our current short-sighted prejudice against genetically-modified foods, but such thinking is likely to disappear within a generation or so, as a growing number of people realise they can either eat genetically-modified foods… or not eat. Indeed, this choice is already being faced by some developing economies today.

Anyhow, we are learning from all the ISS research going on over our heads that plants can grow in microgravity relatively-easily, as long as we deal with a few basic practicalities. Plants will be quickly starved of the carbon dioxide that they need for photosynthesis, if the air around them is not circulated. Since hot air doesn't rise in microgravity, the only way you can get air circulation in microgravity is with some kind of a fan. Similarly, plants rooted in soil will have a problem when water is added to the soil, since the water won't sink, it will just sit there, filling up all the air spaces, which starves the roots of oxygen. However, this issue can also be easily managed by watering the soil using hydrophilic wicks, which can draw water from a sealed container via capillary action.

As we have learned to overcome these minor issues, it has become clear that plants seem much less dependent on gravity than many other Earth-based organisms. For example, since roots generally grow downwards on Earth you might assume that in microgravity they would grow in random directions. But no, plants grown near a light source will always orientate themselves so that their leaves grow towards the light and their roots grow away from it. The location of water and nutrients may also influence the direction in which roots grow.

Plants really do seem to thrive in space, perhaps because their needs are simple: light, water, CO_2, oxygen, warmth and a few trace elements – and it seems that gravity is entirely optional. Of course, these plants wouldn't last a day in space without human intervention, but that's what symbiosis is all about – we need them and they need us.

There are several research facilities on the ISS which are dedicated to establishing our future space-based interdependency with plants. There is the Advanced Biological Research System, currently situated in the Destiny module, which has two identical growth chambers capable of independently controlling temperature, illumination, and atmospheric composition. The ABRS can grow plants, as well as fungi, small insects and other arthropods. Its two growth chambers can be used to compare different environmental effects on the same organism – or to run two totally different experiments. The ABRS is where most research on genetically-engineered plants is undertaken. It is primarily operated from the ground and sends most of its data straight back to the ground, the astronauts only needing to do periodic checks on it or troubleshoot the system if something goes wrong.

The Lada Greenhouse is a joint Russian and US collaboration that has the primary purpose of identifying the best designs for space greenhouses and the most efficient cultivation methods for growing plants in those space greenhouses. With Lada, the astronauts play a much more active role in looking after the plants. Indeed, one of the facility's research goals is to explore whether *space gardening* might deliver positive psychological benefits for astronauts.

As the poet Minnie Aumonier once said: *When the world wearies and society ceases to satisfy, there is always the garden*. Growing plants in space may give future long-haul astronauts something to occupy themselves with, as well as providing them (while millions of kilometres away from home and family) with something to *nurture*. And, of course, they would be nurturing with a real sense of purpose, since their plants will be keeping them well fed and keeping their air breathable.

The newest plant research facility on the ISS is the Vegetable Production System, which was installed aboard the Colombus module in 2014. Commonly known as Veggie, this system also gets regular attention from the ISS crew and it draws in cabin air for its salad vegetable crop via a bellows system, converting at least some of the crew's exhaled carbon dioxide into edible plant material via photosynthesis. For safety' sake, the astronauts have not eaten any of the produce yet, it just gets returned to Earth for testing – but if it all checks out, perhaps a tasty rocket salad might be on the menu.