Background

The United Nations/European Space Agency (ESA) Fellowship Programme on the Large Diameter Centrifuge (LDC) Hypergravity Experiment Series (HyperGES) is a competitive opportunity part of UNOOSA's Access to Space for All Initiative. The fellowship allows a selected research team to conduct their own hypergravity experiment at the European Space Research and Technology Centre (ESTEC), which is part of ESA, in Noordwijk, the Netherlands. Learn more about the fellowship here.

The first team to win the fellowship, from the Faculty of Science of Mahidol University in Bangkok, Thailand, will be working on an experiment focused on developing a new source of oxygen and food for space exploration. We spoke with the team leader, Tatpong Tulyananda, Ph.D.

The LDC facility at ESTEC. Credit: ESA

- **How did you find out about HyperGES and what motivated you to apply?**

I have a PhD from Virginia Tech in biological sciences, and my research focuses on how plants adapt to environmental changes. My first encounter with the space sector was visiting a friend working at US company SpaceX in Hawthorne, California. Seeing their headquarters, laboratory and prototypes prompted me to think of possibilities to apply my research to the space field, by exploring how plants can adapt to space conditions. Once I was back in Thailand, together with other colleagues, we prepared a white paper on "Frontier Research on Earth Space System" that paved our way to space-related research, including on plants in space. Shortly after my appointment at Mahidol University as a faculty member, I was involved in Thailand's National Space Exploration program (NSE). That is when we started a research program on watermeal, a floating aquatic plant that is common in Thailand and in other parts of the world, as potential future food source for space exploration missions.

With our team, we conducted research on how watermeal reacts to hypergravity. The watermeal plant is tiny, no more than 2 mm in size, and it floats on water surfaces, together with other aquatic plants. What sets watermeal apart from other aquatic plants, however, is that it is the fastest growing flowering plant on Earth. This means it can go through the photosynthesis process and generate oxygen particularly rapidly. We are hoping that it could do so also in space conditions: this is the founding hypothesis of our project.

Studying watermeal in the lab.

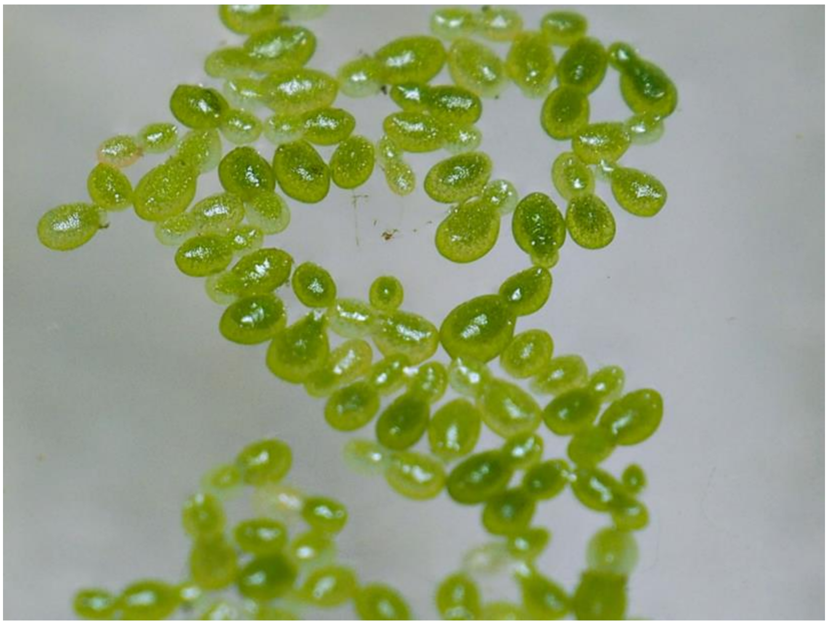
The opportunity to apply to HyperGES came at a perfect time, when our research into the reaction of watermeal to hypergravity conditions was already under way. With our existing equipment, we were able to test our hypothesis for just two hours. To be able to complete the research, needed to keep the plant in a hypergravity environment for much longer, at least 4 days, to cover the full watermeal life cycle. When we learnt that the HyperGES fellowship would allow us to use the facility at ESTEC, where we could run our experiment for days with spinning in hypergravity conditions, we were really excited about this possibility. At ESTEC, we will be able to measure the growth rate and adaptation of the plant to hypergravity conditions over its life cycle. This project will likely be the first ever to study a full plant life cycle under hypergravity conditions.

One day, we would like to test our experiment in space, and we have applied for a research grant from the Thai government to do so, but they have many experiments lined up and we will have to wait. In the meanwhile, testing our hypothesis in hypergravity conditions on Earth, such as those at ESTEC, is the best alternative.

- **What does your experiment consist of?**

In our experiment at Mahidol University, we spun the watermeal to assess the potential damage done by hypergravity. In the two hours of testing we were able to do at Mahidol, the plant did not show any physical damage. Its growth rate and nutrition components were also unchanged after the experiment, so it seems watermeal can tolerate an extreme level of hypergravity, at least within a short period.

If our upcoming longer experiment at ESTEC is to confirm this result, this would open huge possibilities to use this plant in space exploration. It would mean the plant could grow and reproduce on a space station, without suffering damage from the launch conditions.


Newly collected watermeal from a local pond.

The future of space exploration depends on research on how Earth organisms perform under extreme conditions, especially changes in gravity.
Microgravity is when the resulting gravity forces over a body are nearly zero and can be experienced in free fall, for example in a space station. Hypergravity, instead, is when the forces acting on a body are higher than Earth's gravity. An everyday example of hypergravity is the force that a person experiences while going up in an elevator. Hypergravity is also experienced in rocket launches and capsule re-entries, as well as in planets with higher gravitational pulls than Earth. Microgravity research is essential for deep space travelling, and hypergravity research can help us eventually plan an interplanetary life, with humans spending extended periods of time on other planets.
If our experiment proves that the plant can survive a launch to space, then this plant would be a perfect candidate for the next stage, to potentially survive on another planet, which may have higher gravity than Earth.

- **What new possibilities could your research open for space exploration?**

There are multiple possible uses of the watermeal plant for space exploration. The first one is as a “recycler”, breathing in carbon dioxide emitted by astronauts and converting it into oxygen. Because the plant is so small and simple, it is low maintenance and doesn’t spend much energy on other processes. While the plant would not be enough as main source of oxygen for a space mission, it could be a precious back-up. This line of research is quite innovative, as most existing ones have focused on plants as sources of food in space, rather than of oxygen.
Which brings me to the second use the plant could have: in Thailand, we already consume watermeal as food – we even have a company that uses it to make drink and ice cream. Watermeal has a complete range of nutrition components. Many publications have already confirmed the nutritive power of water meal: it is rich in protein, fibres and other nutrients. While one cannot make a complete diet out of it, because it would not provide enough calories, watermeal can certainly offer a decent base of nutrients.

A single watermeal frond lives 5-6 days, but, in just 4-5 days, it can reproduce to double its number. Therefore, it should be possible to grow watermeal as a source of fresh food in space. The plant does need some water to survive, which is “expensive” to bring to space in terms of trade-offs, however we also discovered the plant can survive with just a minimal amount of water.

Watermeal under stereo microscope.

There has already been research around algae for generating oxygen and biomass for food production in space. However, it is hard to consume algae directly, as it needs to be filtered first. One key advantage of watermeal is that it can be harvested and immediately eaten with minimal processing. On top of its simplicity for consumption, watermeal should also taste better than algae.


At Mahidol University Open House, students are welcome to interact with the watermeal plant.

- **Do you think your research could benefit also life here on Earth?**

If, through our research, we were to identify the minimal conditions necessary to produce watermeal in space, these could also be applied on Earth. We have to assess the light, the temperature requirements, and find the minimal energy resources for the plant to still yield a good production. These could be used to grow the plant indoors here on Earth at a lower cost.

- **What is the composition of your team?**

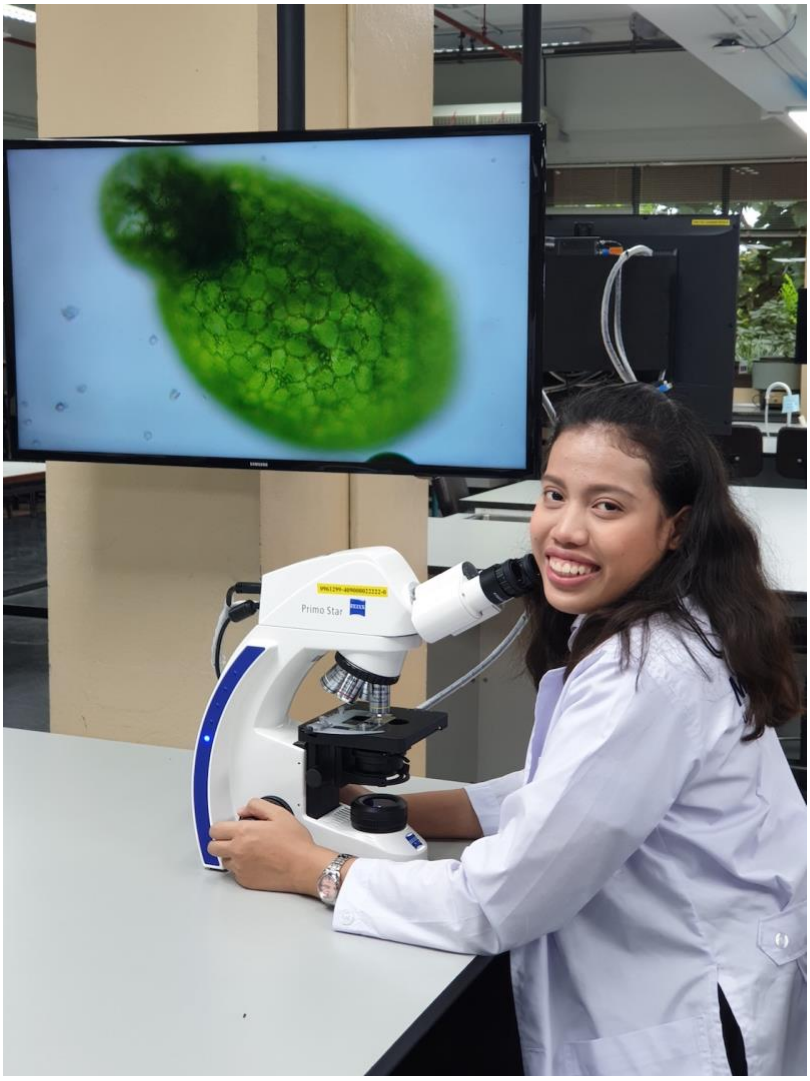
My background is plant adaptation to environment, especially to temperature, and now to gravitational response. In addition to myself, there are four students from Mahidol University in the team, each with a complementary set of skills and a different field of specialty.

Team member Ms. Sutamas Satthong is a 4th year undergraduate student in the Bioinnovation international program. She is studying the proteins profile of watermeal under hypergravity. One way to detect plant responses to extreme gravity is through protein expression.

Ms.Natcha Jitsuk is a 1st year Ph.D. student in physics and she will analyse the movement of the plant and its growth, how the plant gets together, separates, or else.

Mr.Wattanapong Sittisaree is finishing his Ph.D. on algae physiology and metabolism. He will be able to tell us whether and how the photosynthesis process of the watermeal changes under hypergravity conditions.

Mr. Noppon Somanawattana is a 4^{th} year bachelor degree student in electrical engineering, who will be in charge of constructing the experimental box, sensors and programming.



Team member Sutamas Satthong observing watermeal budding under microscope.

The different skills of our team members are very complementary and have a huge potential when combined. Most of the team members have not been exposed to research at the international level before, so this fellowship also provides them with an exciting opportunity to expand their horizons and network.
This project can inspire scientists from other fields to conduct research on space through collaborations with international institutions. As we do not have all the facilities to conduct research on space conditions ourselves in Thailand, international cooperation is the answer.

- **How was the news of your team winning the HyperGES fellowship received in Thailand and at your institution?**

When we got the news from UNOOSA that we had been selected as winners, we were under lockdown due to COVID-19, so we were not able to celebrate all together. The National Astronomical Research Institute of Thailand (NARIT) and the Geo-Informatics and Space Technology Development Agency (GISTDA) are Thailand's major space-related institutions, but they focus mostly on physics and engineering, while Mahidol University has expertise in biological and medical sciences. This is the first space biology project from Mahidol to reach the international stage. When we won the HyperGES fellowship, it was a big deal, not only within the university, but also in Thai media.

We are working to involve the local community here in Thailand in our research: I have presented our project to elementary and high school students, setting up hands-on experiments on watermeal through microscopes. This kind of activities can inspire the next generation of scientists to lead us to even more important discoveries.

Students from Thai schools interacting with the watermeal plant.

- **How do you think your experiment can contribute to the space sector in Thailand?**

Thailand is known as the kitchen of the world: we are one of the main exporters of agricultural products. Given this expertise, conducting research on securing food for humans beyond Earth was in a way a natural fit for our scientists. If our experiment confirms the viability of watermeal as a source of oxygen and food for space exploration, Thailand could lead new research avenues on supplying space missions with nutritious food. In 2021, Thailand publicly announced the establishment of a "Thai Space Consortium (TSC)" composed of 12 research institutes and universities, including Mahidol. I believe TSC will pave the way for the future of the Thai space sector.

- **What are your dreams after HyperGES, where do you think your research may lead you?**

Beside watermeal, I would be interested in conducting research on the possibilities of bringing more nutritious and economically important plants in space, such as rice. In Thailand, we are rice experts: we produce many different species of rice, with different sizes and harvesting time, of very high quality. By studying the variety of rice phenotype, we may find the ideal candidate to cultivate in space. I have colleagues in the rice department in Thailand and, together, we could identify a kind of rice that uses fewer resources and that could be fit for space travels. The first step would be to assess the impact of radiation on rice seeds: we would have to bring the rice to space in seed form and see whether the seeds could survive the radiation and extended storage period.
If we were to find a viable rice type to grow during space travel, this would open doors for longer space missions and even for colonising other planets. If we are to take the leap in space exploration to Mars and beyond, relying just on preserved food from Earth is not enough.

A student prepares watermeal for a short hypergravity treatment before protein analysis.