

HyperGES: The Platform to Boost Space Exploration Capacity and its Contribution to the SDGs



Interviewee: Dr. Marta Filipa Simões, Team Leader, Macau University of Science and Technology (MUST), Macao Special Administrative Region, China

Dr. Tatpong Tulyananda, Team Leader, Mahidol University, Thailand

Date: Interview conducted with MUST on 12 September 2023 and with Mahidol University on 19 September 2023

Background:

The [United Nations/European Space Agency Fellowship Programme on the Large Diameter Centrifuge Hypergravity Experiment Series \(HyperGES\)](#) is offered by the [United Nations Office for Outer Space Affairs \(UNOOSA\)](#) in collaboration with the [European Space Agency \(ESA\)](#), under the [Access to Space for All initiative](#). HyperGES aims to contribute to the promotion of space education and research in hypergravity, particularly for the enhancement of relevant capacity-building activities in developing countries. HyperGES provides opportunities for up to two weeks at ESA's largest [European Space Research and Technology Centre \(ESTEC\)](#) in Noordwijk, the Netherlands to conduct on-site experiment integration and perform hypergravity experiments at the Large Diameter Centrifuge (LDC) facility. The LDC allows samples to be exposed to acceleration forces of 1-20 times Earth's gravity. UNOOSA supports the travel expenses of the team, while the use of the LDC facility, technical support, and accommodations are sponsored by ESA.

In the past two rounds, three teams were selected as the awardees of HyperGES. A team from [Mahidol University](#), Thailand, was selected in 2019 for the first round to study the effect of hypergravity on watermeal, the smallest and fastest-growing flowering plant on Earth. Two teams, one from the [Universidad Católica Boliviana "San Pablo"](#) of Bolivia and the other from the [Macau University of Science and Technology](#) of Macao, China, were selected as awardees in the second round in 2023. The projects of both teams are related to life sciences, a field that benefits immensely from augmented gravity conditions. The project of Universidad Católica Boliviana "San Pablo", proposed by an all-female team, will examine how hypergravity affects the break-up of human red blood cells to get a better understanding of anaemia in space. Macau University of Science and Technology will analyse the medical and biotechnological potential of fungi for future space exploration. Both teams aim to generate knowledge and help create solutions for sustainable development and human well-being.

This interview series is focused on the two teams that conducted their experiment series in September 2023. The Bolivia team is scheduled to conduct their experiment series in December 2023.

3rd ROUND DEADLINE FOR APPLICATIONS: 12 NOVEMBER 2023

FIND ALL THE DOCUMENTS AND REFERENCE MATERIALS
at the HyperGES Rounds page:

https://www.unoosa.org/oosa/en/ourwork/access2space4all/HyperGES/HyperGES_Rounds.html

Other Useful Documents:

Visit the HyperGES awardee's page for more information on each of the teams:

<https://www.unoosa.org/oosa/en/ourwork/access2space4all/Awardees.html>

Interview: First, we talked with Marta, who is the Team Leader of the 2nd round awardee, Macau University of Science and Technology.

Q: What is the objective of your project, and why did your organization decide to work on it?

Fungi are among the least studied organisms in microbiology. They have a profound impact on life on Earth and can also affect space exploration. They are known to change and have different properties under different environments. That is why they adapt well to all sorts of environmental conditions and changes. From the previous research and literature review, we know that under certain conditions, fungi change both their genetic and phenotypic profiles, as well as metabolic, among others. Fungi are commonly found in space stations and spacecrafts. Some of them can become health hazards or contribute to the degradation of infrastructure, while others can be highly useful for in-situ production processes and supporting space missions' sustainability. That is why we want to research fungi under different environmental conditions. We want to know if they change their phenotypes or genotypes, if they behave differently, produce different things, or increased quantities of their bio-products.



MUST team, André Antunes, Marta Filipa Simões, Yang He (Left to right) ©Marta Filipa Simões & MUST

Q: Why did you decide to undertake this hypergravity experiment project? What benefits do you see in a hypergravity environment?

During space exploration missions, especially long-term space missions, special attention should be paid to microbes, as they could be hazards for the mission or be useful materials. We need to know the impacts of microbes once they are exposed to different conditions. We are interested in understanding whether we can use them for resource utilization or if we need to be extra careful because we might end up being more susceptible to infections, especially because the human immune system tends to be affected in space conditions.

“We cannot have sustainable human space exploration without having microbes involved.”

We have been experimenting with simulated microgravity, and we wanted to compare fungal development and potential in different gravity conditions besides the ones we are currently testing. Hypergravity is another environment that can affect fungal growth and development. Furthermore, research published on fungi under hypergravity is very limited. So far, only two species have been reported as having been tested under this setting. With this opportunity, we expect to cover several different aspects by selecting several different fungi with relevance for clinical microbiology, biotechnology and space exploration. After exposing the selected fungal species, we will be testing several parameters, morphology, genetic stability, and production of enzymes, secondary metabolites and metal nanoparticles, to analyse the effect of hypergravity to those species.



Marta and André were collecting samples from the Large Diameter Centrifuge (LDC) at ESTEC.

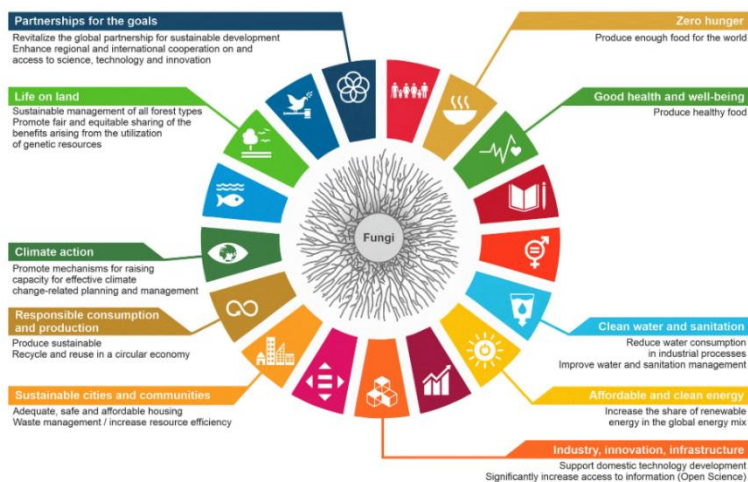
The experiments we are conducting here are to understand fungi better, helping us benefit and prevent harmful aspects of fungi. We cannot have sustainable human space exploration without having microorganisms involved. Any additional outcomes from this experiment can be applied to further research in the space environment. We can also understand, change, adapt, and it could lead to discoveries that might have useful applications to our planet. It is a win-win in both fields.

Q: How does your project contribute to capacity building in developing countries and solving the SDGs? How has it helped you and your organization/country?

Fungal biotechnology can advance the transition from our petroleum-based economy into a bio-based circular economy and has the ability to sustainably produce resilient sources of food, feed, chemicals, fuels, textiles, and materials for construction, automotive and transportation industries, for furniture and beyond. (Meyer et al, 2020)¹. We believe that fungal biotechnology has the potential to make a substantial contribution to climate change mitigation and fulfilling the United Nations' sustainable development objectives.

Fungi can be useful in various things, from foods to different industry areas. They have many applications, including the production of medical drugs, components of textiles, and cleaning up pollutants. In our experiment, we will focus on several fungi and their byproducts relevant to biotechnology and linked industries, drug development, and clinical areas. With the outcome we will achieve from our research, we may be able to enlarge the understanding of fungi and support 10 SDGs as shown in the figure.

Our team is committed to contributing to the following SDGs through our project; SDG 4 "Quality Education" by particularly through outreach activities and science divulgation, bringing science closer to the general public and society, and showcasing our research in regular local school visits to our labs; SDG 8 "Decent Work and Economic Growth" by creating opportunities to those interested in developing scientific work at our laboratory; and, SDG 9 "Industry, Innovation and Infrastructure", through the future development of new materials using byproducts flagged in this mission as potentially relevant.

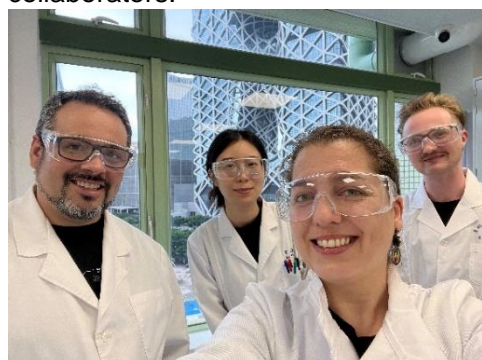


Fungal biotechnology has the potential to make a significant contribution meeting 10 out of 17 United Nation's sustainable development goals through the rational improvement of filamentous fungal cell factories (Meyer et al. 2020)

Q: How has the Access to Space for All initiative helped your organization?

This HyperGES opportunity allowed us to explore further into what we would not have been able to do without coming to ESTEC and access its unique facilities and range of expertise. The staff at ESA have been very kind and helpful. We have been learning a lot from them, and I am sure that the experience and knowledge we are getting here will benefit our future research. Besides that, it was a way of developing our network and getting to know new people and potential future collaborators.

“Access to unique facilities like the LDC helps us boost our capacity in astrobiology research.”



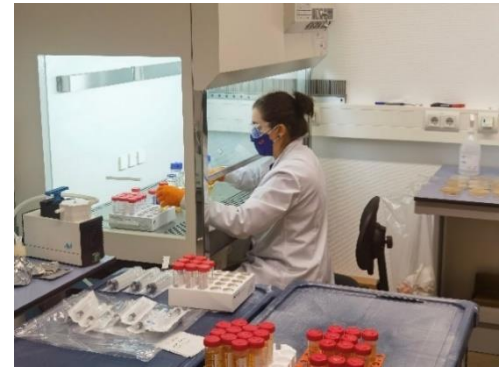
A group photo at MUST ©Marta Filipa Simões & MUST

We see great benefits for our university. We are part of the Chinese State Key Laboratory of Lunar and Planetary Sciences and also part of the Astrobiology research group. Astrobiology is a brand-new research area and we are still at a very early start in establishing this area in Macao. Access to unique facilities like the LDC helps us to boost our capacity in astrobiology research. Unfortunately, we had some last-minute changes as one of our student team members could not join us in Noordwijk. However, everything we have been learning here is beneficial since we are educators, and we will be passing on what we have learned to the students and making sure this knowledge is disseminated. Thus, there are additional trickle-down effects that will be useful in training the next generation of researchers.

¹ Meyer, V., Basenko, E.Y., Benz, J.P. et al. Growing a circular economy with fungal biotechnology: a white paper. Fungal Biol Biotechnol 7, 5 (2020). 20 April 2020, <https://doi.org/10.1186/s40694-020-00095-z>

Q: What are your future plans?

After these series of experiments, we will process our samples and treat our data to clearly know which research direction we will explore further. The opportunity to perform our experiment here also brought us more possibilities for our future research. We have identified a few follow-up threads. We found several interesting new ideas to explore, benefiting from being at ESTEC, conducting the experiments, and discussing with the experts. We now realize that we could have done more tests on additional species or additional combinations. We will be including these aspects in our future research objectives.



Marta doing lab work at ESTEC

“We found several interesting new ideas to explore, benefiting from being at ESTEC.”

Q: Do you recommend HyperGES to other people?

Yes, without any doubt. This is a great opportunity to do experiments in a unique setting and with a level of support that most research facilities do not have. Plus, we get to know more people and researchers with vast experience in different areas of space exploration. This is an amazing laboratory and we got to know amazing people during our stay.



Marta and André with the experts from ESTEC and UNOOSA in the LDC chamber.

Second, we talked with Tatpong, who is the Team Leader of the 1st round awardee team from Mahidol University, Thailand.

Q: Why did you decide to undertake this hypergravity experiment project? What benefits do you see in a hypergravity environment?

When we perform space exploration missions in the future, we are going to face different gravitational conditions, like microgravity or hypergravity, and I believe that basic science is needed to prepare for those missions. Most people focus on microgravity research, like how plants or animals react to this condition, but there are not many teams paying attention to hypergravity. Therefore, I believe that through our HyperGES experiment, we are going to fill in the black box of research for hypergravity. Understanding a broad picture of how plants respond to gravitational alteration and extreme environments is a crucial key to success in space agriculture development.



The Mahidol University team Tatpong Tulyananda, team leader is in middle.

Q: How does your project contribute to capacity building in developing countries and solving the SDGs? How has it helped you and your organization/country?



Our research contributes to different SDGs, especially to support food security under SDG 2 “Zero Hunger”. In our experiment, the purpose is to study how plants react to extreme environments. In the future, we may face degradation of the environment due to global warming and a plant that can tolerate an extreme environment could help people to produce food here on Earth. With an understanding of plant response under extreme environments, we can select or develop adequate plant cultivars that can adapt or thrive. Furthermore, food security does not have to be only on Earth. It is also an interesting topic when we talk about food security on another planet, for example, Mars. If we could have a system that can produce food on Mars to help space exploration missions, it would be a giant step in the human space exploration milestone.

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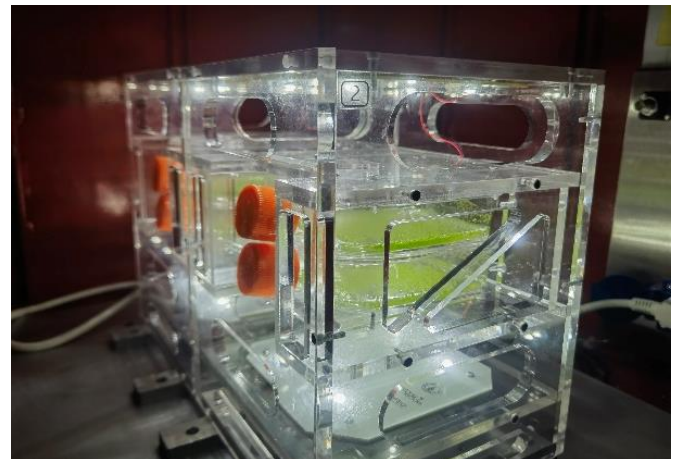


Team member preparing the samples.

Mahidol University has been recently involved in Thai space research initiative. We are getting more interested in space biology at the university. I believe that the research outcomes from our team may help other fields of study at the university. For example, there is a research group that conducts biophysics. Our positive achievements may encourage the university to provide more support to that team and more related research at the university.

Q: What is the objective of your project, and why did your organization decide to work on it?

Our objective through this experiment is to know plant response to gravitational alteration in multiple aspects to develop suitable plant cultivars for space agriculture. Watermeal is a rootless and stemless plant that floats on water bodies. The reason we chose it is because it is an ideal subject for studying the effects of altered gravity on plant development due to its unique characteristics. It is the fastest growing and flowering plant on Earth, it tends to produce more oxygen compared to other small plants, and it can be consumed as food.



Watermeal inside the experiment chamber inside the LDC gondola

At the same time, the plant has the capacity to purify wastewater so we can have multiple functions of plants in the same species. Furthermore, it is a very nutritious plant. It has a lot of protein and other nutritional vitamins and we can consume almost 100% of this plant. We do not know how organisms will respond to an environment that they have not been in before during their evolution. This knowledge helps us to decide on how we prepare for space agriculture for the future,

Q: What is the impact of the Access to Space for All initiative at your organization?

Space technology is becoming a new frontier of research at Mahidol University. Through the Access to Space for All initiative, we were able to work with ESA experts at the Large Diameter Centrifuge, who are at the forefront of hypergravity experimentation. With precious collaborations like this, the initiative provides opportunities for scientists to make connections with experts from around the world. Furthermore, the generous financial support provided by UNOOSA and ESA to realize the experiment campaign is appreciated by developing countries. With the knowledge and experience obtained through this project, we hope to continue and deepen our research at Mahidol University, to develop manpower in this area and become a leader in Thai space research.



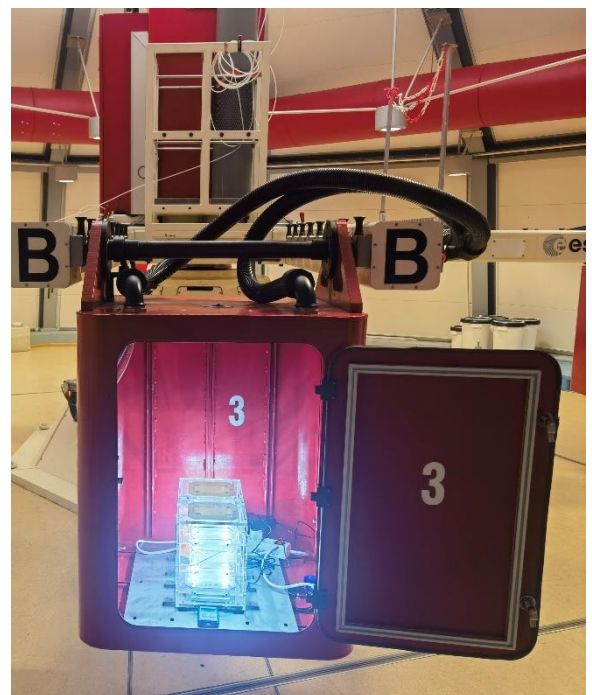
Team members preparing the samples

“The initiative provides opportunities for scientists to make connections with experts from around the world.”

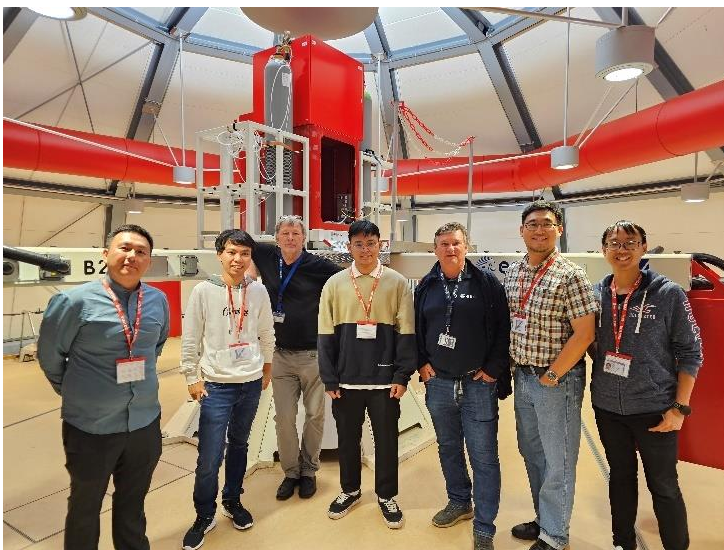
Space agriculture is crucial for sustainable space exploration and that is what we plan for the future. The research on watermeal could be a breakthrough for long-duration space missions. We will continue our close collaboration with ESA in space biology research and expand it to other organizations.

Q: Do you recommend HyperGES/Access to Space for All to other people?

Absolutely! The programme provides an unmatched opportunity for new stakeholders in space technology and research. Besides HyperGES, the Access to Space for All initiative offers many other programs with different disciplines and at multiple levels of research. This is a once-in-a-lifetime opportunity for everyone interested in space technology and research.



Watermeal inside the experiment chamber inside the LDC gondola



Team from Mahidol University with the experts from ESTEC and UNOOSA in the LDC chamber.