About the soybean research project

Background and Vision

Improving germplasm resource preservation, development and application are major scientific research tasks in the National 14th Five-Year Plan. Originating in China, soybeans provide 70% of the world's protein and 28% of its vegetable oil. Soybean cultivation can also reduce the use of nitrogen fertilisers through its symbiotic nitrogen fixing ability, leading to carbon emission reductions. With 80% of soybean demand currently fulfilled by overseas imports due to the shortage of arable land in China, widely adaptive, stress tolerant, high-yielding soybean varieties urgently need to be developed.

The development of aerospace breeding and related technologies bridges the demand gap by integrating China's national strategic agricultural technology with cutting-edge aerospace technology. The committed effort to develop knowledge and capability, and to facilitate innovative research on germplasm resources in space, is empowering technological breakthroughs that will safeguard human and planetary health.

Led by Professor Lam Hon-ming, the State Key Laboratory of Agrobiotechnology (CUHK) research team has been devoted to soybean research project for 25 years – namely the Soybean Homecoming project. The team has successfully defined new directions for soybean genome research by being the first to reveal the genetic diversity of wild soybeans in China using whole-genome sequencing, the first to identify the major-effect salt tolerance gene using an integrated genomic and genetic approach, and the first to construct a reference-grade genome of wild soybeans.

The project has also combined advanced technologies developed by the Hong Kong team with traditional wisdom of mainland Chinese breeders to develop three new stress-tolerant soybean cultivars, Longhuang 1, Longhuang 2 and Longhuang 3. The cultivars, co-developed by Hong Kong and Gansu researchers, have been distributed to local farmers in Gansu province for humanitarian use. The research project has also been included as an example in the STEM education curriculum, benefiting Hong Kong students.

About Space Agriculture Research for Soybean Breeding and Related Technology Development

Rhizobia - Rhizobia are nitrogen-fixing bacteria that form nodules in symbiosis with the roots of legumes and convert atmospheric nitrogen into nitrogen compounds for their plant hosts. When rhizobia meet the legumes in soil, they migrate from the soil to the soybean roots, stimulating them to form small spherical nodules. Soybeans provide rhizobia with organic substances and energy, and rhizobia can store up nitrogen in plants and the rhizosphere via symbiotic nitrogen fixation.

Previous research by Prof. Hon-Ming Lam's team and his collaborators at China Agricultural University yielded fruitful results in the genomics and proteomics of rhizobium. By studying the mutagenesis triggered by the space environment and

conducting space biology research, this project aims to explore the changes in rhizobia upon space loading. After collecting the rhizobia samples from space, the research team will conduct further research. They hope to develop stress-tolerant rhizobia strains with improved nitrogen fixing efficiency, broadening the use of rhizobia, reducing chemical nitrogen fertiliser use, improving soil conditions and contributing to a greener, more sustainable environment.

Longhuang Soybean Series – Professor Lam Hon-ming jointly developed the Longhuang soybean series with his collaborator Professor Zhang Guohong at the Gansu Academy of Agricultural Sciences, tailored for field application in Gansu province's geographical conditions. The soybean series is widely adaptive, with excellent salt and drought tolerance and disease resistance. Approved by the Gansu Province Agricultural Variety Approval Committee for field application in 2016, the Longhuang series has been distributed to farmers in Gansu for cultivation at no cost. Until 2022, they had been planted in an area of more than 55,000 hectares, bringing local farmers additional income of RMB69 million.

The unique conditions of space, including the radiation, microgravity and hyper-vacuum, could cause genetic mutations in the soybean seeds, which in turn will affect how the beans grow. Integrating space mutation breeding techniques with modern agricultural biotechnology, this project aims to conduct research and breeding activities that will further improve the Longhuang series. Investigations on the soybean samples after they return from space will include trait comparison, genome identification, adaptation testing, variety assessment and others, screening for potential candidates for field application to enhance China's soybean productivity.

Space Agriculture Research Proposal

- Rhizobia, with soybeans, can fix nitrogen in the air and convert it to nitrogen in soil for crop absorption. The comparison between extra-vehicular and intra-vehicular rhizobial experiments could unveil important changes in symbiotic bacteria in space, and screen new rhizobia with promising application prospects.
- Longhuang 1, Longhuang 2 and Longhuang 3, developed and approved for field application in Gansu, will be carried into space to induce mutagenesis in a space environment. Comprehensive investigations will be conducted with the returned samples to identify phenotype and genotype alterations. The research aims to uncover space mutagenesis mechanisms, screen new soybean seed materials with promising application prospects, and enrich national strategic agricultural germplasm resources.
- Making use of aerospace materials, integrated research using the latest genomic technologies and smart agricultural technologies can advance national reserves of technical knowledge and drive the momentum of research on the ground.
- This space agriculture research could enhance Hong Kong's role as an international innovation and technology hub.

- This space agriculture research will help STEM education in Hong Kong, allowing youngsters to better understand cutting-edge science and issues related to food security, a sustainable environment and national development.