Gene edited indoor veggie gardens, advanced wastewater treatment to tackle food crisis

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Ensuring food security requires innovative research and solutions. Credit: National University of Singapore

Climate change, rising populations, and shrinking farmlands are all threatening global food security. As the future of food hangs in the

balance, innovative research and the development of sustainable urban food solutions could tip the scales back in our favor.

At NUS, research groups have been working on solutions to tackle the impending food security crisis. Three teams recently secured funding from the Singapore Food Agency (SFA) for their work focusing on sustainable urban food production. These projects aim to increase the productivity of local food producers while balancing key factors like cost-effectiveness, sustainability, and climate resilience.

These three NUS projects are funded under the SFA's Singapore Food Story Research and Development (R&D) Program which aims to develop the local agri-tech R&D ecosystem, and sustainable urban food solutions to support Singapore's "30 by 30" goal for food security.

Improved varieties of leafy vegetables for urban farms

As a land-scarce country, Singapore imports most of its food, making it vulnerable to global food supply disruptions. Urban farming in controlled environments could be a promising solution for Singapore to improve its food self-sufficiency, but its success relies on having robust crop varieties and optimized growth conditions with low environmental footprints.

The team led by Prof Yu will create improved varieties of leafy vegetables for urban farming by using either classical breeding approaches or advanced gene-editing methods. Three varieties of choy sum are shown here. Credit: Yu Hao

Currently, food crops grown in indoor farms are not the ideal cultivars customized for controlled environments. This causes unsustainable crop production, with low yields and limited quality, while incurring high operating expenses. Therefore, a team led by Professor Yu Hao, Head of NUS Biological Sciences, is looking to develop high-efficiency breeding pipelines to improve the genetics of popular leafy vegetables such as choy sum and kale, so that they are better suited to urban controlled environments.

Prof Yu and his team members, comprising Associate Professor Chew Fook Tim from NUS Biological Sciences, and Dr. Shen Lisha from Temasek Life Sciences Laboratory, will develop new breeding technologies which can select key plant traits for indoor farming, such as growth rate, crop yield, nutrient level and plant architecture. They will then create new leafy vegetable varieties with enhanced yields and nutritional values that are tailored for indoor production environments.

They will also develop efficient breeding strategies that can create a variety of food crops for urban farming systems.

"Our project's success will contribute to boosting food security and create a sustainable urban farming industry in Singapore. It will not only create improved crop varieties with desired traits that have immediate commercial values for indoor farming, but also develop research capabilities for breeding of other novel crops for sustainable development of globally competitive indoor farming industry in Singapore," Prof Yu said.

Keeping local fish healthy and free from viruses

Aquaculture—the farming of fish, shellfish, and aquatic plants—is an important food-producing sector in Singapore. However, high-intensity fish farming is often hampered by viral diseases that cause significant losses in aquaculture. In particular, nervous necrosis virus (NNV) and scale drop disease virus (SDDV) are two major viral infections afflicting the Asian seabass commonly farmed in Singapore. Unfortunately, there are currently no available vaccines against these two viruses.

A fish farm in Singapore. Credit: He Jianzhong

To address this issue, Professor Yang Daiwen from NUS Biological Sciences and co-Principal Investigator Dr. Mookkan Prabakaran from Temasek Life Sciences Laboratory, aim to develop vaccines against NNV and SDDV that can be delivered orally or via immersion of the fish larvae and fingerlings. The vaccines will be based on virus-like particles which have similar shapes as the naturally occurring viruses, but are non-infectious.

"The methods developed in this project will also facilitate the production of fish vaccines against pathogens other than NNV and SDDV," Prof Yang said.

The research team also hopes that the development of these vaccines could bring about long-term economic and societal benefits for Singapore, by increasing the sustainability of the country's fish-farming

industries.

Using microbes to filter waste from fish farms

Sewage from fish farms is rich in nutrients like nitrogen and phosphates, and causes huge increases in phytoplankton populations. Commonly known as algal blooms, these phytoplankton can have severe impacts on aquatic biodiversity, and even produce neurotoxins that can enter the food chain and threaten human populations.

The team led by Assoc Prof He Jianzhong (left) is looking into the use of specialised microbes to remove excessive nutrients from fish farms. Credit: National University of Singapore

A major goal of modern wastewater treatment systems is the removal of

nitrogen and phosphorous. This is an economical and effective approach that can be readily adapted to different environments, and could decrease the impact of nutrient deposition from aquaculture facilities in Singapore.

Associate Professor He Jianzhong from NUS Civil and Environmental Engineering is developing a solution to filter the nutrients out of liquid waste from fish farms. This method involves exposing bacteria that consume nitrogen and phosphate to the wastewater from the fisheries.

"A sustainable technology is the key to maximize the output of the aquaculture. Here we employ specialized microbes to remove excessive nutrients from fish farms to boost productivity," Assoc Prof He explained.

By using a microbial bioreactor optimized to remove excess nitrogen and phosphorus from aquaculture wastewater, Assoc Prof He and her team hope to enable the local aquaculture industry to thrive and expand without damaging the ecosystems on which it depends.

Provided by National University of Singapore