

《Sustainable food production looking up》

A laboratory worker in full biohazard gear is patrolling rows of rainbow colored LED-lit shelves. The shelves stand about 2 meters and have six levels, each containing trays of lettuce saplings bathing underneath the light, and the room is illuminated in a psychedelic pink.



A laboratory worker in biohazard gear checks the growth of lettuce in the vertical farm in Anxi, Fujian province.
ZHAN ZHUO / FOR CHINA DAILY

This is no scene from a science fiction movie, but a common sight for scientists at a plant factory in Anxi, Fujian province, which covers 1 hectare and is the largest vertical farming complex in the world. The second-largest is a 0.64 hectare farm in Newark, New Jersey.

Vertical farming is the practice of growing vegetables and fruits in vertically stacked layers of hydroponic solutions in a controlled, indoor environment. It does not require soil, sun or pesticides, and uses far less water and fertilizer than conventional farms.

However, the farm's high-energy cost has greatly limited its scale and profitability. In recent years, Chinese

scientists at the Anxi plant factory have mitigated the issue by inventing energy efficient LEDs and recyclable hydroponic solutions, as well as new energy-conserving methods to maximize a plant's growth potential.

San'an Sino-Science, the company behind the project, says these new methods have cut the factory's overall energy consumption by 25 percent compared with its first facility.

"We hope to cut more energy so vertical farming can become a viable way to feed our population without polluting and straining our already scarce water and soil resources," the factory's executive manager, Zhan Zhuo, said.

"The technology would also allow astronauts, aircraft carrier personnel, and frontier guards on islands or in deserts to grow fresh produce in impossible conditions to fill their daily vitamin and fiber needs."

China has 160 million hectares of farmland dedicated to growing vegetables. To grow them, farmers use more than 311,000 metric tons of pesticide and 59 million tons of fertilizer a year, said Li Shaohua, director of San'an Sino-Science's Photobiology Industry Institute.

"The excessive yet inefficient use of fertilizers and pesticides has done great harm to our environment," he said. "It's high time we find a sustainable and green way to protect our food security."

San'an Sino-Science was founded in 2015 by San'an Group and the Chinese Academy of Sciences' Institute of Botany. The second-generation plant in Anxi can produce 1.5 tons of vegetables, such as lettuce and cabbage, a day.

At full capacity, when the energy cost is neglected, it can produce 1,000 tons of leafy greens a year in theory, according to Li. "The high productivity is mainly because we try to emulate the most ideal natural conditions for plant growth, and use technologies to cater to their every needs."

Before entering the plant factory, visitors must put on a dual-layered jumpsuit, goggles, a face mask, rubber gloves and boots, and be disinfected from head to toe. Sneezing in the factory is strictly prohibited.

"The standard here is stricter than hospital operating rooms," said Zheng Yanhai, a botany researcher at the institute who works at the plant factory. "Because all the plants are growing in nutrient-filled hydroponic solutions, we do not want germs to get into the liquid and make plants sick."

Thanks to the clean environment, plants can grow without antiseptics or pesticides, "you can even eat it fresh out of the bag", Zheng added.

In addition to sanitation, scientists also take temperature, humidity, air circulation, light, carbon dioxide, nutrients and other elements into account to create the "perfect environment" for growth.

A tightly controlled environment not only maximizes growth potential, but also allows scientists to create food that suits specific needs, Zheng said.

For example, scientists can lower the amount of potassium from lettuce for patients with kidney problems or increase zinc in cabbage for children by altering the nutrient solution and growing conditions.

"This is the fundamental difference between a plant factory and conventional farm," he said. "We simply have extensive control over how and when our plants can grow, and let nature run its course in the most ideal conditions."

The requirements for plant growth fall into two broad categories: photosynthesis and soil nutrients.

The sun accounts for 90 percent of all botanic bioenergy through photosynthesis — a process in which plants combine carbon dioxide and water and turn them into carbohydrates and oxygen. Sunlight is a bundle of different wavelengths of light across a wide spectrum from ultraviolet to infrared.

Plants are "picky eaters that favor blue and red lights", Li said. "If we can figure out what ratio and combination of lights are best suited for each plant's growth, then we can change or create LED lights that shine at that specific intensity and spectrum, saving lots of energy in the process," he added.

While blue and red lights are the "meat and potatoes" of a plant's growth, scientists notice other spectrums of light also play a subtle role in maximizing growth and quality.

For example, scientists discovered that adding some green light to the red-blue recipe could help some vegetables grow, while too much green light puts plants into hibernation, although this is helpful for the plant's nutrient build up.

"Mimicking sunlight using LED is very energy intensive," Li said. "At the end of the day, whoever has the most energy-efficient and productive light recipe wins."

While plant growth mostly relies on light, water and carbon dioxide, it still needs some trace elements from soil or fertilizers to be healthy. In the case of plant factories, hydroponic nutrient solutions infused with 17 essential elements ranging from nitrogen to calcium have replaced the tilted soil.

"The content of the nutrient solution is also tailored to suit the plant's specific needs," said Pei Kequan, a research director at the factory. Unlike the trace elements from fertilizers, which are locked in big compound molecules, "the nutrients in the solution are broken into small molecules, meaning the plant can absorb them easier and grow faster while keeping its nutrient value and taste".

It takes about 20 days for a sapling to reach maturity in the lab, but 40 to 60 days in a conventional farm. This means scientists can reap more than a dozen harvests of produce each year, compared with one to two harvests from a conventional farms, depending on the weather conditions, he said.

Moreover, scientists at the facility have built the infrastructure to monitor the elements in the solution. once an element is depleted, scientist can add the missing nutrient and reuse the solution without needing to make a new batch, thus reducing the cost.

"We go to great length to study and cater to our plant's most fundamental needs, making sure they could grow under the best conditions," Pei said. "In a way, the plants are the kings, and we are all its servants."

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