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## **Institute of Botany, Chinese Academy of Sciences and Fujian San' an Group Collaborate to Actively Promote the Emerging Plant Factory Industry Post-Print**

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### **Abstract**

In the inaugural year of the 13th Five-Year Plan, the Institute of Botany, Chinese Academy of Sciences achieved remarkable success in technology transfer. In June 2016, Fujian Zhongke Biology Co., Ltd., jointly established with the Fujian San' an Group, built the world' s largest single-unit Class 100,000 clean vegetable plant factory production facility (with no more than 100,000 particles larger than 5 microns per cubic meter of air). The facility cultivates vegetables across nearly 10,000 squar...

### **Full Text**

#### **Preamble**

In the inaugural year of the 13th Five-Year Plan, the Institute of Botany, Chinese Academy of Sciences achieved remarkable success in technology transfer. In June 2016, Fujian Zhongke Biology Co., Ltd., jointly established with the Fujian San' an Group, built the world' s largest single-unit Class 100,000 clean vegetable plant factory production facility (with no more than 100,000 particles larger than 5 microns per cubic meter of air). The facility cultivates vegetables across nearly 10,000 square meters, producing 1.5 tons daily of green, pollution-free, high-quality vegetables that have already entered the market. In photobiology R&D, the institute completed the first-generation light formula technology for lettuce production and developed a corresponding lighting system for production applications, achieving ideal results. Additionally, 1,000 self-developed cultivation modules were exported to the United States, generating over US\$2 million in foreign exchange.

Plant factories are highly efficient plant production systems with fully intelligent control of growth environments (temperature, humidity, lighting, CO<sub>2</sub>, and nutrient conditions). They represent a knowledge- and technology-intensive agricultural production method that integrates innovations from modern biotechnology, environmental control, facility horticulture, construction engineering, and computer science. Unconstrained by natural environments, this all-weather, high-efficiency production mode not only dramatically improves land use efficiency but also addresses increasingly prominent food safety issues. Beyond urban agriculture, plant factories hold significant strategic importance and broad application potential in specialized environments such as defense equipment, ocean-going vessels, desert islands, and aerospace. Consequently, plant factories represent a crucial development direction for future agriculture and have been designated as a high-tech strategic emerging industry worldwide, with nations actively building technology reserves and industrial investments. According to industry forecasts, by 2020, the global output value of LED lighting for plant growth will reach tens of billions of dollars, while plant cultivation output value could reach hundreds of billions of dollars. In response, China's research and industrial communities have been actively conducting research in related fields in recent years, achieving substantial breakthroughs and practical results.

The Institute of Botany, Chinese Academy of Sciences is China's oldest comprehensive plant science research institution. Over its nearly 90-year history, it has developed distinctive disciplinary characteristics and advantageous fields, producing numerous important academic and R&D achievements in plant diversity and evolution, vegetation and environmental change, photosynthesis, growth and development, environmental responses, and resource exploration. These accomplishments include three First-Class Prizes and six Second-Class Prizes of the National Natural Science Award. During the 13th Five-Year Plan period, the institute will focus on major fundamental theoretical questions in plant science and the critical needs of China's ecological civilization construction and agricultural transformation development. Centering on disciplinary advancement and national strategic demands, it will vigorously develop basic plant science, applied R&D, and public service support systems, with plant factory technology representing one of its key research directions.

San'an Optoelectronics Co., Ltd., under the Fujian San'an Group, is one of China's earliest, largest, and highest-quality industrial bases for full-color ultra-high brightness LED epitaxial wafers and chips. It is a "National High-Tech Industrialization Demonstration Project" enterprise approved by the National Development and Reform Commission and a "Leading Enterprise in Semiconductor Lighting Engineering" recognized by the Ministry of Science and Technology. Leveraging independent intellectual property rights, the company has mastered plant growth lighting technology and developed specialized LED chips for cultivating vegetables, fruits, flowers, medicinal herbs, and other crops. Its wholly-owned subsidiaries possess mature industrial support in industrial automation, CNC precision manufacturing, and special light source production, along with an international management team, providing strong support for

the company' s entry into new fields.

## 1 Strong Alliance, Complementary Advantages

After multiple mutual visits and in-depth discussions, the Institute of Botany and the San' an Group decided to leverage their respective expertise accumulated over many years in plant photosynthesis and other agricultural science technologies, as well as LED spectral technology, to achieve complementary advantages and jointly promote the industrialization of plant factories in China. Following thorough evaluation, the Institute of Botany reported its cooperation intentions and specific measures with the San' an Group to advance plant factory technology R&D and industrialization to the CAS headquarters, receiving high recognition and approval from President Bai Chunli. At the end of October 2014, both parties formally signed a cooperation agreement to jointly build a plant factory, with Vice President Zhang Yaping witnessing the signing ceremony.

To promote closer integration between scientific research and physical industry, the two sides collaboratively established the "Plant Factory Research Institute." The Institute of Botany recommended Researcher Li Shaohua as its director, with over ten renowned scientists from China and abroad serving as scientific advisors. The institute established research directions targeting plant lighting, biopharmaceuticals, equipment research, resource development, and testing and inspection. It organically integrates photobiology, horticulture, nutrition, botany, and phytochemistry, fully leveraging the advantages of the Institute of Botany' s plant biology and San' an Optoelectronics' core LED technologies. Addressing China' s strategic needs in plant resource development, food quality and safety, and plant factory industrialization, the institute aims to build an innovative technology R&D platform for plant factories, establish an industrialized technical system, and promote the industrialization of plant lighting products, intelligent system equipment, factory-scale cultivation of biopharmaceutical raw materials, and innovative drugs for major diseases. Utilizing the enterprise' s advantages in technology, capital, and talent, the initiative will first establish large-scale demonstration bases in China' s major megacities to provide consumers with green, pollution-free, high-quality vegetables, fruits, and health foods, while also setting up demonstration bases in key international regions to promote system equipment and related technologies with independent Chinese intellectual property rights.

## 2 Innovation-Driven, Rapid Development

On January 6, 2015, the Institute of Botany' s 120th administrative meeting decided to establish the "Plant Factory R&D Center" and a technical guidance committee, with Academicians Kuang Tingyun and Fang Jingyun serving as co-directors. The institute selected four PhD researchers for long-term deployment at the San' an Group to conduct technology R&D and provide technical support.

After nearly a year of innovative R&D and technological breakthroughs, the deployed researchers and San' an Group' s scientific personnel achieved significant progress in plant light formulas and lighting products, plant nutrient solution formulas and recycling technologies, and plant variety screening and cultivation methods. In December 2015, the Institute of Botany and Fujian San' an Group jointly established "Fujian Zhongke Biology Co., Ltd." (abbreviated as "Zhongke Biology" ), an emerging photobiology industry project integrating scientific research, production, demonstration, and incubation functions. The project has a registered capital of RMB 100 million and a total investment of RMB 7 billion, comprising three core components: the Zhongke Biology headquarters, the Plant Factory Research Institute, and the Zhongke Biology industrialization base. The Institute of Botany holds a 10% stake through intellectual property contributions. In January 2016, then CAS Vice President Academician Zhan Wenlong inspected the Zhongke Biology headquarters and industrialization base and held discussions with Zhang Zhinan, Executive Vice Governor of Fujian Province, as well as representatives from the Institute of Botany and San' an Group. Subsequently, the plant factory project was listed as a key cultivation direction in the CAS "13th Five-Year Plan" and received support from the CAS Bureau of Science and Technology for Development' s STS (Science and Technology Service Network Initiative) program. Concurrently, the project was also designated as one of Fujian Province' s key supported initiatives.

### 3 Scientific Support, Initial Results

Since its establishment, Zhongke Biology has made excellent progress within one year: securing 200 mu (approximately 13.3 hectares) of land for the Plant Factory Research Institute and 300 mu for industrialization. At its first industrialization base in Hutou Town, Anxi County, Fujian Province, the company has begun producing high value-added vegetables, fruits, and Chinese medicinal herbs, while also conducting raw material processing for innovative drugs. Under the care of CAS leadership and the scientific support of the Institute of Botany, the first vegetable plant factory entered trial production within six months, with the first batch of plant factory-produced vegetables entering the market in August 2016. Currently, high-quality, safe vegetables have been launched at over 100 retail outlets across Xiamen, Fuzhou, and Quanzhou in Fujian Province, receiving high praise from consumers.

Although China' s plant factory industry is still in its infancy, it will undoubtedly expand into a new industrial cluster, forming upstream and downstream industrial chains with independent intellectual property rights, and delivering significant social, economic, ecological, demonstration, and science education benefits. This will make entirely new contributions to human health industries, agricultural industrialization, and biopharmaceutical innovation. The Institute of Botany will further strengthen R&D on plant factory industrialization technologies, focusing on the main battlefield of national economic development to safeguard enterprise growth.

(See inside front cover for related images)

*Note: Figure translations are in progress. See original paper for figures.*

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