Project Number: 101081858
Project Acronym: ECONUTRI
Project title: Innovative concepts and technologies for ECOlogically sustainable NUTRIent management in agriculture aiming to prevent, mitigate and eliminate pollution in soils, water and air

Demonstration Sites
Status as in M28

7. CHINA AGRICULTURAL UNIVERSITY, (CAU)

7.1 Description of the demonstration site (location, infrastructure, activities).

Demonstration Site 1：Vegetable Waste Composting and Ultra-High Temperature Composting Technology

China Agricultural University conducted various composting and land application experiments on vegetable waste in both laboratory settings and at the "Sharing Harvest Organic Farm" in Shunyi District. The research explored the mechanisms of harmful substance removal and nitrogen and phosphorus emission reduction during the composting and field return process of vegetable residues. During this period, ultra-high temperature composting technology was employed to treat vegetable waste.

To optimize greenhouse gas emissions during composting, six different ingredient optimization groups were established. In the land application phase, 15 different land application models were developed to explore greenhouse gas emission reduction strategies. Additionally, to enhance the value-added utilization of on-site composting and land application of vegetable residues, the study also investigated the safety, disease suppression, and growth-promoting effects of composted vegetable waste products. Specific composting images and field trial results are shown in the figure 2.

The demonstration site will consist of a designated location in the Shunyi District of Beijing, China, known as the "**Sharing Harvest Organic Farm**". The infrastructure and activities associated with this location are outlined as follows.

<u>Location. Sharing Harvest Organic Farm</u>

SFOH (Sharing Harvest Organic Farm) is a modern organic agricultural enterprise covering approximately 23.3 hectares (350 mu) in Longwantun Town, Shunyi District, Beijing, China. It is a subsidiary of Shared Harvest (Beijing) Agricultural Development Co., Ltd. The farm's innovative ecological farming practices have been recognized by the Food and Agriculture Organization (FAO) of the United Nations as a case study for sustainable agriculture. Additionally, China Agricultural University conducts field trials and promotes applications related to "Vegetable Waste Composting and Ultra-High Temperature Composting Technology" as part of WP2 in the ECONUTRI project at the farm's Liyuan Commune. "Application technology of organic base fertilizer and water-soluble fertilizer for organic facility vegetables" carried out at the greenhouse site as part of project WP4.

Figure 1. Overview of the compost and field trials facilities of SHOF.

Figure 2. Compost facilities at SHOF.

Figure 3. Facility vegetable base at SHOF.

Demonstration Site 2： Application technology of organic base fertilizer and water-soluble fertilizer for organic facility vegetables

In this Demonstration Site, China Agricultural University aims to solve the problems of insufficient soil nutrient supply and low nutrient utilization rate in cucumber production in organic facilities, as well as environmental problems such as nitrogen and phosphorus leaching, salinization and greenhouse gas emission caused by excessive water and fertilizer input. By supplementing the organic available nutrients during the critical period of crop nutrients and combining with the nitrogen recommendation system based on the soil-crop process system model to optimize nitrogen application management, the aim is to improve vegetable yield while reducing environmental risks.

The demonstration site's other base at the Shared Harvest Farm is also located in Shunyi, Beijing with a vegetable planting area of 5.3ha, including 32 greenhouses and nearly 2.7ha of open land,mainly to grow vegetables. Cucumbers are usually planted in March, and seedlings are pulled in July. The experimental sites are equipped with field weather stations, static box, tension meter, soil water sampler and other test equipment.

Figure 4. Overview of the greenhouse facilities of SHOF.

<u>The problem addressed</u>

The trials carried out mainly focused on the slow supply of organic fertilizer nutrients and the inconsistency with crop nutrient requirements. The main types of fertilizers used in organic agriculture are manure, compost and other organic fertilizers applied to the field. The nutrient release law of such fertilizers is affected by various factors, which usually shows that the release rate is fast in the early stage and slow in the later stage. The traditional law of organic fertilizer supply is contrary to the law of crop cultivation, resulting in low nutrient utilization efficiency and production reduction. In order to pursue economic benefits, farmers blindly increase the input of organic fertilizer without considering the balance of nutrient supply and demand, resulting in nutrient waste and adverse environmental impact.At present, in conventional agricultural production, the research on the recommended technology of vegetable nitrogen fertilizer has been relatively mature. By clarifying the input and output of each link of nitrogen balance, the application amount of nitrogen fertilizer can be determined to ensure production and reduce nitrogen loss at the same time. However, such technology is rarely used in organic agricultural production.

<u>The solution provided by the innovation shown in the Demonstration Site</u>

According to the nutrient requirements of cucumber in different growth stages, the application of organic fast fertilizer was carried out with the nitrogen expert recommendation system based on the soil-crop process system model. Specific research and application include :1) Screening different organic water-soluble fertilizer sources through field experiments. 2) Establish a DSS system suitable for organic facility vegetable cultivation. The innovative technologies on display at the demonstration sites address the inefficiency of nutrient use caused by improper nutrient management in organic agriculture. Different types of organic fast-available water-soluble fertilizers were screened to optimize fertilization management measures for vegetables in organic facilities. The effects of different fertilization treatments on soil nutrient content and fertilizer supply rules were explored by measuring the content of mineral nitrogen and available phosphorus in surface soil. The balance calculation of soil nitrogen components, including soil nitrogen mineralization, nitrogen leaching and crop nitrogen uptake, was carried out by using nitrogen expert recommendation technology based on soil-crop management model. In order to maintain the soil nitrogen buffer value, the quantitative calculation of organic water-soluble fertilizer application was carried out according to different growth periods of crops. Under this optimization scheme, the environmental impact of nitrogen and phosphorus leaching loss, greenhouse gas emission, soil EC value and so on during crop growth were evaluated. The program was evaluated from three aspects: nutrient supply and demand balance, crop production and environmental impact.

7.2 Description of the innovation(s) shown in the Demonstration Site.

Demonstration site 1:

The technology demonstrated at SHOF involves the application of 'Vegetable waste composting and ultra-high temperature composting technology'.

The problem addressed

The annual generation of vegetable waste in China is estimated to be 250 million tons, primarily consisting of discarded leaves, stems, and roots from large-scale vegetable production. Improper disposal of these residues, such as open dumping or uncontrolled decomposition, can lead to severe environmental issues, including nitrogen and phosphorus leaching, greenhouse gas emissions, and the proliferation of plant pathogens. Conventional composting methods often struggle to efficiently degrade complex organic matter while simultaneously mitigating these environmental risks. The technology demonstrated at SHOF involves the application of Vegetable Waste Composting and Ultra-High Temperature Composting Technology, which enhances the degradation efficiency of vegetable residues while reducing harmful emissions. Ultra-high temperature composting (>80°C) accelerates organic matter decomposition, effectively inactivates plant pathogens and weed seeds, and minimizes methane and nitrous oxide emissions. Moreover, this process promotes the stabilization of nitrogen and phosphorus, thereby reducing nutrient loss and improving the agronomic value of the composted product. Despite these advantages, the precise mechanisms underlying harmful substance degradation, greenhouse gas emission reduction, and nutrient stabilization during ultra-high temperature composting remain insufficiently understood. Furthermore, the optimal parameters for compost formulation and land application strategies require further refinement to maximize the environmental and agricultural benefits. Current research efforts at SHOF focus on optimizing compost ingredient composition, refining high-temperature process parameters, and evaluating the efficacy of composted vegetable waste in improving soil health, suppressing plant diseases, and enhancing crop growth in field applications.

The solution provided by the innovation shown in the Demonstration Site

The novel technology demonstrated at the Demonstration Site is specifically designed to address the challenges associated with the large-scale disposal of vegetable waste, which leads to severe environmental pollution and nutrient losses. The Vegetable Waste Composting and Ultra-

High Temperature Composting Technology explores the effects of high-temperature microbial decomposition in accelerating organic matter degradation, stabilizing nitrogen and phosphorus, and reducing greenhouse gas emissions. Through the ECONUTRI project, significant progress has been made in optimizing compost formulations to improve degradation efficiency while minimizing harmful emissions. By implementing a synchronized regulation approach that integrates ingredient optimization during composting and strategic land application models, this strategy effectively enhances the removal of harmful substances from vegetable waste while reducing nitrogen and phosphorus losses. The ultra-high temperature composting process (>80°C) ensures the complete inactivation of plant pathogens and weed seeds, creating a safe and high-quality organic amendment for agricultural use. Additionally, this technology involves analyzing the relationship between compost formulation, greenhouse gas emissions, and soil fertility improvement under different land application conditions. By developing 15 distinct land application models, the study aims to establish an optimized greenhouse gas reduction framework for composted vegetable waste utilization. These insights enable precise control over compost application strategies, enhancing soil health while mitigating environmental risks. This methodology establishes a coordinated regulatory system encompassing compost formulation, ultra-high temperature processing, and land application, which significantly enhances the value-added utilization of vegetable waste while reducing nitrogen and phosphorus pollution. Through this integrated approach, the project promotes a sustainable and circular agricultural waste management system that aligns with environmental protection and resource recycling objectives.

7.3. Already performed activities

Demonstration site 1:

After a year of systematic experimental research, the CAU team has made significant progress in developing Vegetable Waste Composting and Ultra-High Temperature Composting Technology. This innovative technology integrates compost quality improvement with greenhouse gas emission reduction by comparing the effects of different auxiliary material additions during the composting and land application stages. By optimizing auxiliary material types and land application methods, the study has significantly reduced greenhouse gas emissions while simultaneously enhancing compost quality and soil nutrient composition. The key elements of this technology are detailed as follows:

Greenhouse gas emission reductions

To address the issue of high greenhouse gas emissions during the composting of vegetable waste, this study implemented Ultra-High Temperature Composting Technology for vegetable waste treatment. To optimize greenhouse gas emissions during the composting process, six different ingredient optimization groups were established. At the land application stage, 15 different land application models were developed to explore greenhouse gas reduction strategies during compost utilization. Furthermore, to enhance the value-added utilization of on-site composting and land application of vegetable residues, we also investigated the safety, disease suppression, and plant growth-promoting effects of composted vegetable waste products.

Modified soil nutrient content

Based on the treatment group settings in the composting and land application stages, we further explored the effects of different composting and land application methods of vegetable waste on soil nutrient content. Additionally, we conducted a comprehensive evaluation of soil quality and soil safety. As a result, we identified the optimal field application method for composted vegetable waste, achieving the best soil improvement and sustainable utilization outcomes.

Efficiency of novel technology demonstrated in SHOF

The application of this technology has demonstrated a significant reduce greenhouse gas emissions. Specifically, in the composting stage, the addition of corn syrup achieved the best greenhouse gas emission reduction, with CO_2 reduced by 17.6% and N_2O reduced by 49.9%. In the land application stage, direct land application after crushing was the most beneficial for greenhouse gas reduction, resulting in the lowest GWP of 66.18 kg·hm^{-2}.

Additionally, in terms of soil quality, the secondary addition of corn syrup was more beneficial for improving overall soil quality. Regarding soil safety, land application after composting helped reduce the relative abundance of pathogens in the soil, with crushing and land application reducing pathogen levels by 15%–30%, compared to 5% with composting.

1. Title: Impact of different vegetable residue compost and returning methods on global warming potential (GWP)	
Start time: 09/21/2023	End time: 11/29/2023
Short description: In the composting stage, the addition of corn syrup achieved the best greenhouse gas emission reduction, with CO_2 reduced by 17.6% and N_2O reduced by 49.9%. In the land application stage, direct land application after crushing was the most beneficial for greenhouse gas reduction, resulting in the lowest GWP of 66.18 kg·hm^{-2}.	

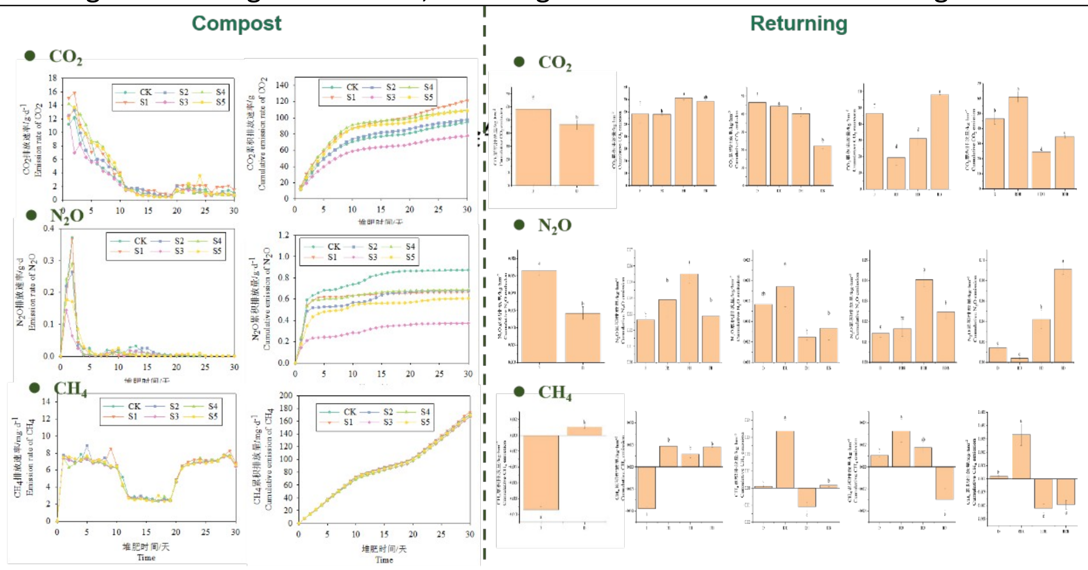

Figure 5. GHG Emission Results of Vegetable Waste Treatments with Different Composting and Returning Stages.

2. Title: Soil nutrient modification effect after returning vegetable waste to the field in different compost treatments of vegetable waste	
Start time: 02/27/2024	End time: 06/24/2024
Short description: In terms of soil quality, the secondary addition of corn syrup was more beneficial for improving overall soil quality. Regarding soil safety, land application after composting helped reduce the relative abundance of pathogens in the soil, with crushing and land application reducing pathogen levels by 15%–30%, compared to 5% with composting.	

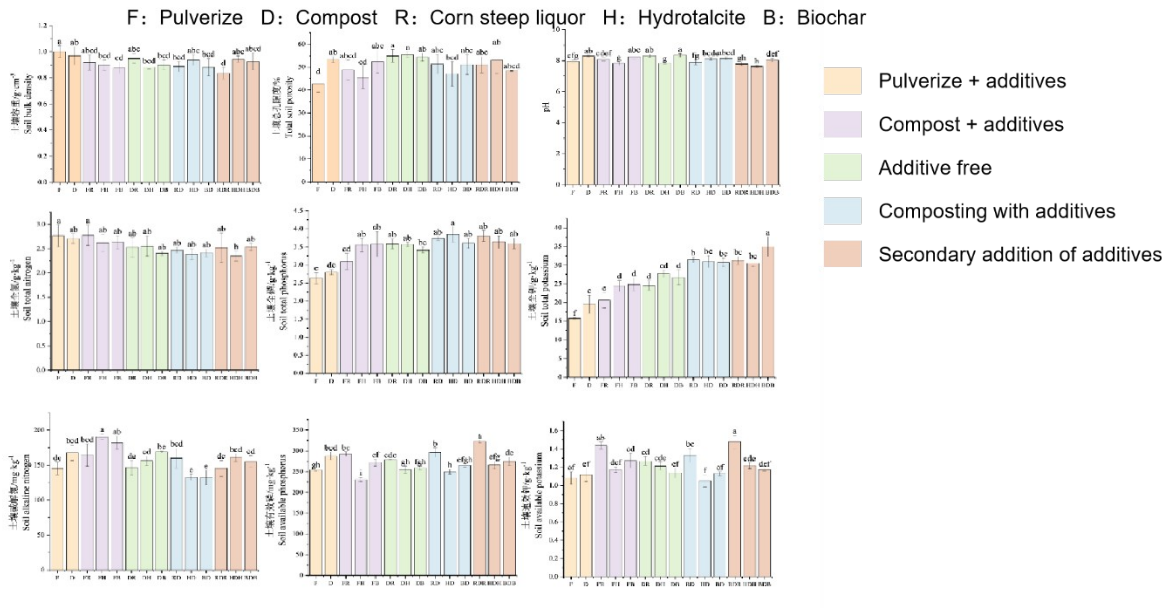

Figure 6. Soil nutrient modification effect after returning vegetable waste to the field in different compost treatments of vegetable waste.

<u>Demonstration activities organized by CAU</u>

1. On April 9, Professor Dimitrios Savvas, the project's European coordinator, visits the “Sharing Harvest Organic Farm” demonstration site.

Figure 7. Prof. Dimitrios Savvas came to “Sharing Harvest Organic Farm” for an academic mentoring exchange.

2. On June 24, the task leader from the European side, Lidia Sas-Paszt, Director of the Department of Microbiology and Rhizosphere Studies at the Polish National Horticultural Research Institute, was invited to China for an exchange.

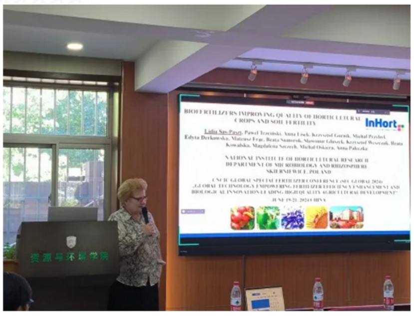

Figure 8. Prof. Lidia Sas-Paszt came to China for academic exchange in China Agricultural University.

3. On July 20, the 2024 mid-term meeting of the ECONUTRI project and the Technology Specialist Training and Exchange Meeting was successfully held in Heihe City. Wang Anqi, a PhD student of Prof. Chang Ruixue, leader of Task 2, attended the meeting. On July 21, Wang Anqi gave a progress report on Task 2.2 and 2.3 of WP2, "Safe Treatment of Livestock Solid Waste and Vegetable Straw and Application of Functional Products in Land Use." In the afternoon of July 21, she visited important research platforms, including the Nitrogen and Phosphorus Reduction Technology Demonstration Base for Crop Rotation under Soybean and Maize Conditions, the Soybean Breeding Base of Heihe Branch, and the National Field Observation Station, along with project experts, key personnel, and representatives of technical beneficiaries.

Figure 9. Progress report on Task 2.2 of WP2 "Vegetable Straw and Application of Functional Products in Land Use."

Demonstration site 2:

After a year of systematic experimental research, the CAU team has made significant progress in developing the combination application technology of organic slow acting fertilizer and fast acting fertilizer. This innovative technology, by screening different organic fertilizer sources and applying them quantitatively according to the DSS system, significantly improved nutrient use efficiency and increased yield without causing significant environmental impact. The key elements of the technology are detailed below:

<u>Balance of nutrient supply and demand</u>

To solve the problem of low nutrient utilization efficiency in cucumber production in organic facilities, three different organic water soluble fertilizer sources were screened, including enzymatic hydrolysis amino acid fertilizer (plant source), fish protein fertilizer (animal source) and Bacillus subtilis bactericide (microbial source). The soil inorganic nitrogen content is monitored every ten days or so, and topdressing is started when the soil inorganic nitrogen content is lower than the soil buffer value (100kg/ha). By collecting plant samples at each growth stage of cucumber and measuring nitrogen uptake, soil nitrogen supply and crop nitrogen uptake were compared and analyzed, and the effect of technology on crop nutrient utilization efficiency was evaluated.The results showed that the three kinds of fertilizers could better balance the balance of soil nitrogen supply and demand and significantly increase the yield of cucumber.

Environmental impact

In terms of environmental impact, soil samples of 0-90cm were collected to determine the contents of inorganic nitrogen and available phosphorus to characterize nitrogen and phosphorus leaching, and greenhouse gases were sampled every 1, 3 and 5 days after topdressing. The results showed that the treatment of amino acid fertilizer and fish protein fertilizer significantly increased the emission of N2O, but the other indexes had no significant effect.

1. Title: The decision support system was initially constructed to provide precise nutrient input for organic cucumber production	
Start time: 03/19/2024	End time: 07/20/2025
Short description: Three different organic fertilizer sources were screened for topdressing. The expert nitrogen recommendation system was used as the framework of the decision support system, and WHCNS model and field experiment were used to collect data, calculate the application amount of each topdressing, and control the soil inorganic nitrogen content to maintain at the buffer value. Specifically, Cucumber can meet the nitrogen requirement of crops in most of the time of fruiting, production increased by 34.0%-42.1%.and does not cause obvious excessive nitrogen input.	

Figure 10. Three tested organic water-soluble fertilizers

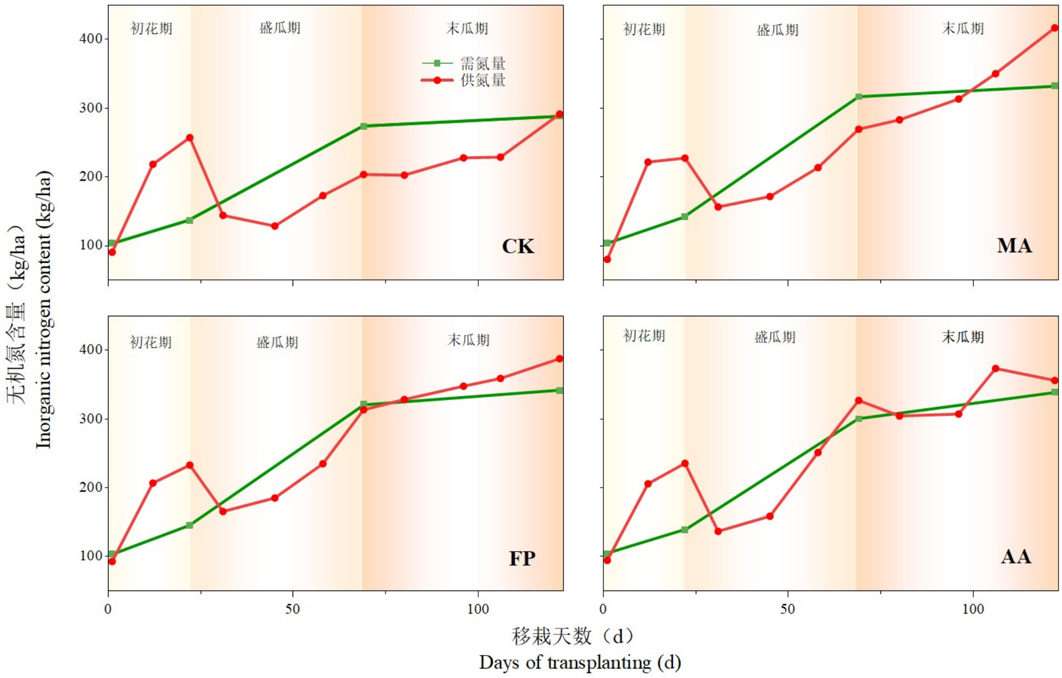

Figure 11. Balance of nitrogen supply and demand in cucumber under different topdressing treatments

Demonstration activities organized by CAU

2024.4.9 Professor Rodney Thompson and Professor WimVoogt went to the Shared Harvest organic farm demonstration site, visited the experimental field where the nutrient management task of organic agriculture was carried out in the project, and had an in-depth exchange on the follow-up of the experiment.

Figure 12. Prof. Rodney Thompson and Professor WimVoogt visited the CAIW demonstration site

2024.5.2 The European Chief of the ECONUTRI Project, Prof. Dr. Dimitrios Savvas, visited the Share and harvest organic farm demonstration site and discussed the use of DSS in organic agriculture.

Figure 13. Prof. Dr. Dimitrios Savvas visited the CAIW demonstration site

2024.6.24 Prof. Lidia Sas-Paszt, Head of the Department of Microbiology and Rhizosphere of the Polish National Horticultural Institute, visited the Beijing Experimental Station of the Shared Harvest Farm.

Figure 14. Prof. Lidia Sas-Paszt visited the CAIW demonstration site

2024.07.05 China Agricultural University undergraduate students visit the demonstration site.

Figure 15. China Agricultural University students visit

2024.08.26 Training activities for farmers and consumers are conducted from a series of levels, such as the development, current situation, planting, breeding and mode of organic agriculture.

Figure 16. Training activity

7.4 Planned activities for the next year.

Demonstration site 1:

Sharing Harvest Organic Farm (SHOF)

In 2025, SHOF plans to continue the development of the WP2 framework for vegetable waste carbon sequestration and emission reduction treatment technologies. The aim is to investigate the impact of vegetable waste treatment and utilization processes on soil nitrogen and phosphorus transformation and leaching.

China Agricultural University (CAU)

The CAU plan for 2025 and 2026 include the following demonstration activities in the demonstration site of CAU.

1. Organize one demonstration and promotion event for vegetable waste composting technology.
2. Invite foreign cooperative researchers for guidance and academic exchanges.

Demonstration site 2:

The plan for 2025 and 2026 include the following demonstration activities in the demonstration site of Share and harvest organic farm.

1. Optimize the existing DSS system for organic agriculture.
2. The nitrogen and phosphorus emission reduction technology of organic facility vegetable plots in summer was constructed in conjunction with organic water-soluble fertilizer.
3. Organize training to demonstrate and promote the combined application technology of organic quick-acting fertilizer and long-acting base fertilizer based on DSS model.
4. European experts in organic fields are invited to China for technical exchanges on nitrogen and phosphorus emission reduction in organic systems.