# Research Progress and Prospect of Intelligent Tea Garden Technology Application

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**Abstract**　The development and application of internet plus modern tea industry technology is more and more extensive. As an important part of the development process of tea industry, intelligent tea garden plays an important role in the development of the whole industry. At present, intelligent tea garden technology is widely used in many fields such as intelligent monitoring, water and fertilizer integration, green prevention and control, quality and safety traceability. In this paper, the application of intelligent tea garden technology in tea gardens was reviewed. On this basis, the development trend of new information technology and tea industry was prospected, in order to provide some reference and thinking for the innovative research of new technology in tea garden in the future.

**Key words**　Intelligent tea garden, Intelligent monitoring, Green prevention and control, Traceability

## 1　Introduction

As the origin of tea trees, China is the first country in the world to discover and utilize tea[1]. Tea tree is one of the important characteristic economic crops in China. As a major tea producing country, China has a wide planting area of tea gardens. According to the statistics in 2021, China's tea planting area reaches 3. 264 million ha, the total output of dry semifinished tea reaches 3. 06 million t, and 75. 15% of the tea produced is mainly consumed domestically[2−3]. In this way, with the increasing consumption of tea in China, the improvement of tea quality and the rapid integration of science and technology have become the focus of the future development of the tea industry.

With the increasing maturity of various new technologies such as Internet + Internet of Things (IoT) + mobile Internet + 5G network + artificial intelligence + big data + cloud computing + blockchain + sensor technology in China, the implementation of "intelligent agriculture" action is conducive to promoting the standardization of production and operation of modern agriculture and rural development and the intelligence of management services[4−6]. The intelligent agriculture is to apply a variety of new technologies such as IoT to various fields of agricultural production[7]. At present, the standardization, intellectualization and visualization of the production and management of tea gardens in China need the guidance of these new technologies, which will promote the mechanization of modern agriculture while improving the level of agricultural technology and equipment of tea gardens. The close integration of agriculture and information technology promotes the development of intelligent tea gardens, thereby improving the level of productivity in the tea industry.

Intelligent tea garden refers to the establishment of intelligent tea garden control system based on IoT technology, which specifically includes service platform, data transmission network and terminal equipment[8]. In the control system of intelligent tea garden, new science and technology are used to comprehensively perceive, manage, monitor, analyze and share, and then integrate the key information of the whole industry chain to realize the monitoring and management of the entire growth cycle of tea trees, so as to provide professional and reliable data information for the administrative staff of tea gardens. For example, various sensor systems required for the soil environment under tea trees and the overall environmental factors on the ground are installed using IoT technology, to collect and transmit data from various aspects such as soil physical and chemical composition, soil pH, temperature and humidity, light intensity, atmospheric pressure, wind speed and direction of tea gardens via images, video and sensors through real-time monitoring. To realize the transformation and upgrading of traditional tea industry, it is necessary to extend the concept of intelligent tea garden to all fields of the tea industry, so as to promote the development of the entire industry.

Nowadays, with the rapid development of science and technology, intelligent tea garden technology has bee applied in tea production in China. In all aspects of tea production, information technology quickly integrates the allocation of resources related to the tea industry, makes intelligent responses efficiently and quickly, and feedbacks decision-making information, thus promoting the informatization of tea gardens and the traceability of tea production. In this paper, the current application research of intelligent tea garden technology is reviewed, in order to provide some reference for the future application research.

## 2 Intelligent tea garden integrated management cloud platform

Intelligent tea garden management cloud platform is a visual management platform that monitors the whole process of tea production in real time based on the information technology of IoT application and database management system, including the surrounding environment of tea garden planting, growth cycle, climate change, product production, processing and circulation[9]. Through the unified management center, the platform makes decision analysis of various indicator data, and finally adopts the "one graph" technology that can manage all information resources, control all equipments and display relate matters combined with the client management platform, thus completing the visual management of the whole tea garden information[10]. Huang Chenhui et al.[11] transmitted all the information about tea garden environmental factors collected by terminal wireless sensor group to Zig-Bee coordinator using wireless sensing and cloud server combined with remote measurement and control platform, and uploaded tea tree cultivation information to the cloud server after PC processing, and then controlled the device after intelligent decision based on the information, thus controlling the cultivation environment of tea trees. Cai Shaobo et al.[12] acquired data information related to tea garden environment by jointly using LoRa communication network, sensors and MQTT protocol technology, and sent the collected data to the cloud communication platform, through which the client could directly see the data transformed into visual graphics, so as to realize intelligent monitoring of environmental information of intelligent Se-rich tea garden. Based on LPWAN IoT cloud platform technology, Hai Tao et al.[13] uploaded the environmental parameter information of tea garden collected by LoRa and NB-IoT network to the cloud platform; after analyzing and processing the relevant data, the server synchronized it to PC and mobile terminals, and finally realized remote monitoring and intelligent management of tea garden.

Through the established management cloud platform, experts and tea farmers can grasp the situation in the tea garden in real time, and make corresponding safeguard measures or management measures in advance for problems in the production of tea products, and finally realize the "information digitization, production automation, and service networking" of the whole tea industry chain. At present, there are numerous tea industry intelligent parks in China represented by tea enterprises in Fujian Province, such as Wuyixing, Pinpinxiang, Xiangyuan Tea, Yufeng Guoxin, Fujian Nongken Tea Co., Ltd., and Anxi Taoyuan Organic Tea Farm. Wuyixing Company has built an intelligent agricultural information cloud platform using IoT technology, through which enterprise managers of the platform can grasp the production situation of the entire intelligent tea garden in real time. Moreover, the platform will also provide real-time warning, intelligent analysis and remote control, and "one graph" can provide enterprises with precise planting, visual management and intelligent decision-making services.

## 3 Application of intelligent tea garden technology

### 3.1 Intelligent "four conditions" monitoring system of tea garden

The "four conditions" monitoring system of tea garden mainly includes field weather station, soil moisture monitoring instrument, insect monitoring instrument, and video monitoring. By means of real-time monitoring, intelligent monitoring and scientific induction, the system collects data such as tea tree growth, field insect pest situation, soil conditions, ecological environment and climate factors to provide scientific suggestions and guidance for tea garden planting[14-15]. The general environmental "four conditions" monitoring system systematically monitors and manages the meteorological environment of tea garden (light intensity, solar radiation, $CO_2$, rainfall, climate temperature and humidity, atmospheric pressure, wind speed and direction, annual accumulated temperature, etc.), soil moisture (soil pH, soil moisture content, soil temperature and humidity) of tea garden planting base, the situation of insect population of tea trees (number and species of insect pests), and tea tree growth situation and conditions and other indicators. After the data is transmitted to the platform, the indicators are viewed remotely in real time, and accurate adjustments are made accordingly to ensure the healthy growth of tea trees.

In 2022, a small agricultural weather station and soil moisture monitoring station was installed in the tea garden of 666.7 ha in Yibin City, Sichuan Province. Through intelligent IoT environmental monitoring system, various meteorological disasters were warned according to the soil temperature and humidity, electrical conductivity and pH, rainfall $PM_{2.5}$, $PM_{10}$, wind speed, wind direction and other data of the tea garden monitored, so as to realize intelligent tea garden management, and ensure the quality and yield of tea. With the support of the county government, Danzhai in Guizhou Province also launched the East and West cooperation 5G + intelligent tea garden. Through IoT technology, a number of monitoring systems have been built in tea gardens, including video surveillance, product traceability, insect pest monitoring, meteorological analysis, soil moisture, etc., to monitor the growth of tea trees in real time, and realize the digital, intelligent and fine management of intelligent tea gardens. The monitoring station "Nongqibao", independently developed by Fujian Meteorological Bureau, has been put into use in Xiaowuyi Tea Garden of Baiyunyan Tea Factory in Nanping City. The monitoring station mainly carries out automatic monitoring and transmission of tea growth temperature and humidity, light intensity, $CO_2$ concentration, soil temperature and humidity, etc. The "intelligent tea mountain" meteorological demonstration station of Swallow Nest Ecological Tea Garden in Xingcun Town of Wuyishan City was successfully built in 2021. The meteorological station mainly conducts regular,

continuous and positioning observations on ecological temperature, light, ultraviolet, photosynthetically active radiation, air relative humidity, wind direction, wind speed, soil temperature, moisture and precipitation of tea gardens, and digitally manages the planting of "intelligent tea mountain", thus realizing the ecological tea garden construction.

## 3.2 Intelligent integrated water and fertilizer management system of tea garden

The intelligent integrated water and fertilizer management system of tea garden is mainly an irrigation and fertilization system, in which technologies such as IoT, computer and unlimited communication are applied. According to the water and fertilizer required by the growth of tea trees, the system automatically monitors the soil moisture and the type of fertilizer required by the tea garden, and then automatically sets the water and fertilizer rotation irrigation supply plan, to control tea plant growth by optimizing irrigation and fertilization to the maximum extent possible[16-18]. The installation of integrated water and fertilizer systems in tea gardens can increase soil nutrients and improve soil water quality, thus ensuring tea yield and quality[19].

Guizhou Classic Tea Industry Company built an integrated demonstration park of water and fertilizer in tea gardens, and planned multiple systems including automatic fertilization and irrigation, so as to achieve targeted fertilization during the whole growth process of tea trees and reduce fertilizer volatilization and loss. Anhui Qimen Tianzhihong Ecological Organic Tea Garden built an intelligent tea garden control and management system. According to the soil environment of tea gardens, soil nutrient content and water and fertilizer requirements of tea trees in different growth periods, the tea trees are supplied with water, organic matter and nutrients regularly and quantitatively in proportion, so that the material nutrients required for the growth of tea trees can be rationally utilized. The implementation of remote integrated water and fertilizer management operations is also known as "cloud fertilization". Yangzhou in Jiangsu Province and Enshi in Hubei Province have installed drip irrigation water and fertilizer integration systems in mountain tea gardens, proportionally mixing fertilizer liquid and water and spraying the whole tea body by pressure, so as to save time, labor and water in tea garden management and operation. In 2016, Huaxiangyuan completed the patent authorization of tea garden water, fertilizer and drug integrated sprinkler irrigation system, which consisted demand central control system, detection system, access control system, and mixing system, to complete integrated water, fertilizer and drug operations, and improve the automatic management of tea garden.

## 3.3 Intelligent green prevention and control system of tea garden

Intelligent tea garden green prevention and control is mainly based on information technologies such as IoT and big data, and intelligent insect condition prediction and intelligent trapping and reporting systems are installed in tea gardens. In the case of unsupervised, the system will view the insect population situation of the tea garden in real time, automatically complete the operations such as pest counting, insect trapping and killing, photographing and transportation, and improve the disease and pest outbreak and disaster warning and green prevention and control ability of tea gardens through data information operation, so as to promote the development of the tea industry[20-22]. Muchuan County in Leshan City adopts solar intelligent insect situation detector, weather station, and solar IoT insect killing lamp for comprehensive prevention and control of major diseases and pests in tea gardens, reduces diseases and pests to a minimum by realizing insect attracting, insect killing, collection, packaging and cooperation, and achieves 5G + intelligent tea gardens to promote the quality and efficiency of the tea industry. Jinhua City in Zhejiang Province adopts military technology and IoT technology multi-functional intelligent terminal remote control in Tangxi Jiufeng Tea Garden, and controls the population quantity of *Empoasca vitis* by affecting its life habit through acousto-optic control technology, eventually achieving intelligent green prevention and control of the tea garden. In addition, Chachang Village in Longjing District has installed the *E. flavescens* situation monitoring and reporting and target pest acousto-optic precise prevention and control system. *E. flavescens* situation monitoring and reporting system is to predict and warn *E. flavescens* situation through remote image acquisition, processing and intelligent analysis. Based on the acoustic sensitivity characteristics of *E. flavescens*, the acousto-optic precise prevention and control system of target pest emits irregular sound waves to the tea garden to disrupt the communication and spatial positioning of pests and further block the mating and reproduction of pests, and finally emits a specific wavelength light source by remotely controlling light source according to the photosensitivity characteristics of the pest, thus achieving the accurate killing of *E. flavescens*.

## 4 Quality and safety traceability system of tea garden

The quality and safety traceability system of tea garden adopts automatic data acquisition technology and whole-process video monitoring system to establish a traceability system network platform for all aspects of tea tree planting, picking, processing, storage, logistics and sales, so as to realize whole-process supervision of tea product quality and safety[23]. At each stage of teat production, unique identification and video recording are carried out and linked to each other, so that each product has a unique traceable QR code. Under the monitoring of big data, product-related information at each stage is performed "digitized" management, and transparent "identity files" are established to effectively reduce the number of counterfeit and shoddy products. If there is a problem with the product, it can also be traced through the "identity file" mark, which greatly reduces the scope of tea safety problems, and further improves the character and quality of tea. Therefore, the intelligent traceability system ensures the quality safety of consumers from "tea garden" to "tea cup"[24-25].

After investigation, it was found that since 2011, the government of Anxi County, Fujian Province, begun to build an "agricultural materials supervision and logistics tracking platform", and implemented "one product, one code" to clarify the identity, so as to ensure the safety and traceability of tea production inputs. In 2019, the Tieguanyin "digital tea" cloud platform was launched to complete the quality and safety traceability of Tieguanyin tea and real-time monitoring and early warning of the whole industry chain. In 2021, with the support of IoT and other technologies, Zhejiang Jinhua Gengxiang Organic Tea Industry Development Co., Ltd. installed a digital tea production line. In the total control cloud platform of digital production line, staff can view and debug each production line through high-definition surveillance video, and when each machine is operating, the system can collect equipment process data and upload it to the general control cloud platform. After the platform analyzes and integrates the work data, it can better guide the tea processing, realize the transformation and upgrading from "experience tea making" to "digital tea making", and make the tea production more standardized, scaled and digitized in the future. In 2022, Songshan Village, Sukeng Town, Yongchun County, Quanzhou City, established a high-standard intelligent tea garden, including a tea garden traceability live broadcast system and a tea garden production management system. The tea garden traceability live broadcast system is mainly composed of a traceability live broadcast platform, environmental data monitoring and video cameras, which can show the most real situation of the tea garden to consumers and realize remote supervision of tea garden standard planting. Tea garden production management system mainly views the whole process of tea circulation through the cloud platform, including seedling cultivation, sowing, fertilization, maintenance, harvesting, processing, storage, packaging and other links, forming a clear traceability information.

## 5    Conclusions and prospects

In the face of the current development trend of tea industry, the 14th Five-Year Plan is an important strategic opportunity period for the combined development of tea industry and tea science and technology in China. As the world's largest tea producer and consumer, China has regarded accelerating the construction of intelligent tea garden technology as one of the future development goals of the tea industry. The application of diversified information technology will lead the development of intelligent tea gardens in China, promote the transformation and upgrading of traditional tea industry, and enhance industrial advantages, thereby forming a social virtuous circle of increasing farmers' income and enterprises' efficiency.

In the context of Internet plus, the Internet enables "small tea" to become "big industry", actively explores new development models by implementing the Internet plus concept, and drives the sustainable upgrading of the tea industry. Anxi, as the first tea

capital of China, launched the Anxi Tieguanyin 1 satellite into space at the end of 2021, and the intelligent tea industry of Anxi enters the era of "remote sensing + agriculture". Relevant departments, tea enterprises and tea farmers can carry out planning and management assessment of tea gardens by applying big data, satellite remote sensing and modern optical technology, and carry out routine preventive testing and calculation of tea gardens, thus building an intelligent tea industry with cloud momentum. Therefore, it has become the mainstream of future development by combining IoT, blockchain, cloud computing, big data, mobile Internet and other new generation of information technology with all aspects of tea industry production, promoting the Internet plus modern tea industry development and upgrading, and achieving informatization of the whole industry chain. At the same time, it focuses on ecological, green, intelligent, healthy and safe development of tea industry, and realizes the standardization, intelligence, digitalization and informatization of tea industry chain in China.

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tion skills, vocational skills education should be integrated into professional discipline education in talent training programs, and new vocational standards should be incorporated into curriculum standards. In addition, we should actively introduce new technologies and new processes, and incorporate new norms into curriculum standards to improve the quality of talent training. In the talent training program, it is necessary to highlight the importance of vocational skills certificates, increase course hours, strengthen pre-exam training, and improve the certificate passing rate for "1 + X" assessment system, so that more students can obtain certificates before graduation.

**4.4  Strengthening communication with relevant enterprises and improving the "1 + X" certificate system**    At present, the "1 + X" certificate system has just started to be implemented in many colleges and universities, and there are still many problems that have not been encountered and are difficult to solve. Therefore, it is necessary to exchange experience with relevant enterprises regularly, jointly formulate the "1 + X" certificate system, teach each other updated ideas and implementation modes and schemes of the certificate system, improve the shortcomings and problems in the implementation work, optimize and improve the "1 + X" certificate system, improve the recognition of the "1 + X" certificate by relevant enterprises, and increase the employment rate of students.

## 5  Conclusion

Through the above-mentioned research on "1 + X" certificate system, it is clear that the implementation of "1 + X" certificate system is an important strategic policy for the rapid development of vocational education in China by the Ministry of Education in the future development of vocational education in higher vocational colleges. By analyzing the problems in the implementation of "1 + X" certificate system for horticulture majors in higher vocational colleges, this paper puts forward the updated working mode and ideas to provide strategies for accelerating the development of vocational education in southern Xinjiang from the point of view of the improvement of 1 + X certificate system, the reform of talent training program, the improvement of teachers' ability and summing up experience.

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