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China,intelligent agriculture

Design and application research of intelligent agricultural greenhouse measurement and control system

————Take the example of the Ta Yuan Zhuang Tongfu Rural Revitalisation Demonstration Park and the Luquan Comprehensive Experimental Base

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[Abstract]

China is a large agricultural country, and the development of agriculture is related to the country's livelihood. Agriculture is bigger and stronger, fundamentally relying on the modernization of agriculture, and science and technology is the only way to its development. With the continuous improvement of the level of intelligent technology, intelligent agricultural greenhouse technology has broken the traditional agricultural crude planting method, reduced the impact of season and weather and other factors on crops, and promoted agricultural development, and intelligent agricultural greenhouses are being widely used in a large area. In order to better study the application of the measurement and control system in the specific practice of wisdom agriculture, this paper analyzes the operation process and benefits of the greenhouse greenhouse measurement and control system by conducting field research on the Tongfu Countryside Revitalization Demonstration Park (hereinafter referred to as Tongfu Countryside Revitalization Demonstration Park) in Tayuanzhuang, Zhengding and the Luquan Comprehensive Experimental Base (Luquan Comprehensive Experimental Base) of the Hebei Academy of Agricultural Sciences, seeking to demonstrate the broad The research was conducted to analyse the operation process and benefits of the greenhouse measurement and control system.

【Key words】Smart agriculture, measurement and control system, greenhouse, sensors

I. Background of the application of measurement and control systems in greenhouse agriculture

(i) Terminology explanation

Smart agriculture, also known as intelligent agriculture, is a modern over-the-top agricultural production method that uses industrial production to achieve intensive and efficient sustainable development under relatively controlled environmental conditions; it is a production method of intensive scale operation with advanced agricultural facilities and open fields, with high technical specifications and high efficiency. It integrates scientific research, production, processing and marketing, and realises annual, all-weather and anti-seasonal enterprise scale production; it integrates modern biotechnology, agricultural engineering, new materials for agriculture and other disciplines, relies on modern agricultural facilities, realises automated management, promotes precise, efficient and ecological transformation of agricultural production mode, and accelerates cross-penetration and integrated development of agricultural industry and other industries. With high technological content, high added value of products, high land output rate and high labour productivity, it is a cross-century project of China's new agricultural technology revolution.

Greenhouses, also known as conservatories. A facility that transmits light and keeps warm (or heats up) and is used to cultivate plants. It can provide greenhouse fertility and increase production during unsuitable plant growth seasons, and is mostly used for the cultivation of temperature-loving vegetables, flowers, forestry and other plants or seedlings during low temperature seasons.

The measurement and control system refers to the exchange of information through sensing equipment to achieve intelligent positioning, identification, tracking, control and other operations. The measurement and control system can make the process of growing agricultural products more precise and rigorous, reduce the waste of resources and significantly improve production efficiency and product quality.

(II) Application opportunities and motivation

Food has always been a guarantee for the long-term stability of the country and the well-being of the people, and China is a large agricultural country with 200 million workers directly engaged in agricultural production, which has become the main economic source for most rural people to support their families. At present, the hollowing out of the countryside and the shortage of agricultural labor caused by the working economy, the lack of water in some areas, and the deformed agricultural mechanization are increasingly exposed, and the food problem is becoming more and more prominent.China is a large agricultural country but not a strong agricultural country, mainly due to the large population base leading to a relative lack of arable land resources per capita and the relatively scattered distribution of arable land, which prevents large-scale mechanized farming and also indirectly leads to the slow development of the agricultural economy. Therefore, large-scale and standardised production is the main goal of current agricultural development, and smart agriculture is the future direction of agricultural development [1].

Tongfu Countryside Revitalisation Demonstration Park is an agricultural science and technology demonstration park in Hebei Province, which is a plain area. The scope of application of smart agriculture basically covers many fields such as vegetable and fruit greenhouses, flower and gardening greenhouses. Traditional greenhouses have problems with insulation capacity, pressure resistance, temperature control management and productivity. The new greenhouse greenhouses use a measurement and control system to accurately monitor the environmental parameters in the greenhouse to ensure that the crops can be in the most suitable growing environment in the greenhouse. The Luquan Comprehensive Experimental Base is an important platform for the National Centre for Semi-Arid Agricultural Engineering and Technology Research to implement scientific research projects and technology demonstration and promotion. The centre is oriented towards arid and semi-arid areas, and carries out in-depth research on intelligent agricultural greenhouses, and relies on the base to carry out extensive technology integration and promotion work, demonstrating and promoting more than 20 new technologies and new achievements, providing strong scientific and technological support for radiating the development of

surrounding agriculture and increasing farmers' income. At present, the measurement and control system of Tongfu Rural Revitalisation Demonstration Park and Luquan Comprehensive Experimental Base is mainly applied to vegetable and fruit greenhouses and flower and gardening greenhouses. In order to further promote the application, this paper explores the design and application of the measurement and control system.

II. Composition and operation process of the measurement and control system

(i) Measurement and control system architecture

The design of the measurement and control system is to collect environmental parameters through various sensor modules distributed in the greenhouse, and then use the wireless communication network for data transmission and aggregation, and send the data effectively to the server, so that users can monitor and manage online through the visualization interface, realize the regulation of environmental parameters, improve the production efficiency, build the sensing nodes of data collection sensors, acquire data patterns, monitor the temperature and humidity changes in the greenhouse, transmit data analysis and storage [2]. , monitoring temperature and humidity changes in the greenhouse, parsing and storage of transmission data [2].

(ii) Measurement and control system module functions and applications

1. Data acquisition module

To achieve automatic sensing of crop growth environment and growth information, we must first build wireless sensor nodes and carry out hardware and software design of the nodes, and then monitor the information of plant growth environment through various sensors distributed in the greenhouse, mainly collecting parameters such as CO_2 concentration, air temperature and humidity, light intensity, soil temperature and humidity in the greenhouse. The sensors are mostly composed of sensitive elements, conversion elements, auxiliary power supplies and conversion circuits. Understanding the characteristics of the sensors and how to install them is an essential step in the design of a smart agriculture greenhouse system to obtain

real-time data parameters in the greenhouse. The installation of each type of sensor is determined by its role and the data parameters it monitors affect the operation of the entire greenhouse and the growth of the plants. The location of the sensor also determines the accuracy of the monitoring results and the consequences of data distortion are very serious, so the selection and installation of different types of sensors should be carefully considered.

(1) CO_2 sensor

CO_2 sensors are sensors that monitor the concentration of CO_2 in the air in agricultural greenhouses. CO_2 affects both plant respiration and photosynthesis, so it is necessary to install sensors. It is essential to monitor and control CO_2 in greenhouses in order to increase the yield and quality of crops, as most plants need to obtain carbon through photosynthesis, which comes from CO_2 in the air, so if CO_2 levels in plant greenhouses can be maintained at the right concentration by human technology, it will greatly enhance the growth of a large number of crops.

(2) Air temperature and humidity sensors

The air temperature and humidity in the greenhouse has a great impact on plant growth. Air humidity affects transpiration, which is not only the driving force for water absorption, but also for the transport of mineral nutrients. When air humidity is high, transpiration is weak and the plant's ability to transport mineral nutrients is reduced. A prolonged period of low air humidity can cause necrosis at the edges of leaves as well as at the leaf tips. Too much or too little air humidity can cause stomata to close, and with plant stomata closed, CO_2 cannot enter the leaf pulp cells and photosynthesis slows down or even stops. Each plant has its own preferred temperature and humidity, which is controlled according to its characteristics to

Fig. 3 three-in-one sensor for temperature, humidity and illumination of weather environment

ensure the plant's growth. These sensors need to be installed in the middle of the greenhouse, not too high or too low, and adjusted to the actual crop type.

3) Soil temperature and humidity sensors

The soil is needed to grow crops and the temperature and humidity of the soil affects the water absorption by the plant roots, so it is particularly important to monitor and adjust the temperature and humidity of the soil. To monitor the soil temperature and humidity, soil temperature and humidity sensors are installed in the soil near the plant roots. Based on the data monitored by the sensors, the manager can apply the right amount of irrigation to the soil in time.

Figure 4 Greenhouse Greenhouse Cooling Water Curtain

(4) Light sensors

In order for plants to make full use of light energy and better photosynthesis, data on light intensity needs to be obtained and, based on the light intensity of the day, the need for supplemental lighting with fill-in lights is determined. Different planted crops have different needs for light intensity. The system uses a light sensor with a range of 0 to 200,000 to monitor the light in the greenhouse and monitor the changes in light intensity through the cloud platform, so that corresponding measures can be taken to increase the light intensity in the greenhouse, which is conducive to the photosynthesis of crops, promoting the growth of crops, shortening the growth cycle and improving economic efficiency, as well as saving manpower and material resources and improving the management of greenhouses.

2.Computer-based data

Fig. 5 Computer Operation Diagram

analysis module

Through sensors and wireless network to obtain parameters such as CO_2 concentration, air temperature and humidity, light intensity, soil temperature and humidity inside the greenhouse. Using the Smart Farm cloud platform and the plant status database, the information feedback from the above environmental factors is compared with the expected values, and in response to the generated data monitoring results, drive commands are issued to the greenhouse shed standby motors, thus realising the monitoring of environmental quality compliance.

For example, sun-loving crops such as tomatoes and cucumbers have light intensities between 2000 and 25,000 Lux, which are conducive to their growth. After the light sensor acquires the parameters of light intensity in the tomato greenhouse, it uploads the plant status database through the wireless network. The smart farm cloud platform compares the above data with the expected value, and if the light intensity exceeds 25,000 Lux, the platform generates a judgement that the light is too strong and launches a command to the greenhouse greenhouse standby motor to pull the curtain.

3. System regulation and operation module

The data monitoring results inside the greenhouse are analysed and compared with the expected values, and then the motors inside and outside the greenhouse can be controlled by the controller output to achieve shading, irrigation, spraying and fertiliser application. For example, when the light intensity inside the greenhouse is too high, the controller can issue instructions to the motor in the area of excessive light intensity, and the motor can drag the curtain to reduce the light coming in from around the greenhouse of smart agriculture. The control of the motor also focuses on the speed control of the motor, mainly in areas such as irrigation and drug spraying, which needs to be able to irrigate or spray according to the type of crop, the dose of drug or water required, and the size of the area to be sprayed [3].

III. Analysis of the benefits generated by the measurement and control system

(i) Ecological benefit analysis

The comprehensive experimental base in Luquan has gained huge benefits in terms of environmental protection: cultivating seedling soil has reduced disease to 2.5%, saving pesticide costs by 60 %, saving 45% in water and fertiliser costs through a standardised management system, and achieving a 96% seedling rate. Smart agriculture not only incorporates advanced science and technology, but also encompasses the concept of green environmental protection, which on the whole enhances the agricultural production environment, makes the transport and sales management process more scientific, reduces the pollution of the land by excessive use of chemical fertilisers and other chemical fertilisers, eases the contradiction between agricultural development and arable land tension, water shortage and labour shortage, makes the overall production environment a good ecological cycle and greatly improves the sustainable development of agriculture. The overall production environment will be ecologically recycled and the sustainable development of agriculture will be greatly enhanced.

(ii) Analysis of economic benefits

This data is a comparative analysis using the annual average data of cucumber planted from March to August for two years in 2020 and 2021 at the Luzhuan comprehensive experimental base. The base grows cucumbers in six greenhouses, each 1.0 mu, two of which are managed by conventional manual management and four of which are managed by drip irrigation with intelligent control of water and fertilizer integration. The machine well irrigation water flow rate is 45m3/h, the pump power is 18.5kw, the electricity cost is 0.65 RMB/kwh and the labour cost is 80 RMB/worker.

Statistical items	Conventional management	Intelligent management	Benefits (+- %)
Yield per mu (kg/mu)	13600	15200	+11.76%
Irrigation water (m3/mu)	1350	742.50	-45.00%

Electricity cost (yuan/mu)	360.75	212.84	-41.00%
Irrigation labour (yuan/mu)	1600	400	-75.00%

Table 1. Statistical table for economic benefit analysis

Through two years of data analysis in 2020 and 2021, the economic benefits of the intelligent control system are mainly manifested in four aspects: yield, water saving, electricity saving and labour saving. The overall revenue per mu can be increased by more than RMB 3,500 by using integrated water and fertilizer intelligent control. The reason for this is mainly to improve the efficiency of water and fertiliser management, save the amount of groundwater, save electricity consumption, reduce labour intensity, greatly reduce labour and management costs, fertiliser costs, weeding costs, production material costs, and to be able to a certain extent on the yield and quality of agricultural products, and thus enhance the production value.

(iii) Analysis of social benefits

The social benefits generated by the application of the greenhouse greenhouse measurement and control system in Tongfu Rural Revitalization Demonstration Park are manifold.

First, the intelligent farm flower planting → tourism, promoting the integrated development of one, two and three industries, promoting agricultural structure adjustment, realizing green transformation and upgrading, complying with the requirements of the Demonstration Construction of Intelligent Agriculture in Hebei Province, promoting the transformation of traditional agricultural products to special, fine, green, standard and brand, reducing the production cost and transaction cost of agricultural products as much as possible, promoting the product agriculture of the park to functional agriculture, processing agriculture, landscape agriculture, leisure agriculture and agriculture combined with cultural tourism.

Secondly, scientific planting has improved the quality and quantity of crops, guided farmers to shift from the pursuit of increased production to focus on quality,

promoted high-quality green agricultural products, and driven the entire industry towards high-quality, safe, efficient and ecological development. High-quality crops have ensured food safety for consumers and improved the quality of life, and high-quality products can form a brand effect. Due to the high price of related equipment and labour, the crops produced are expensive and the target consumers are mainly high-end consumers, which is important for maintaining social stability in rural areas and driving stable and sustainable income growth for farmers.

Thirdly, the application of intelligent systems saves more manpower to engage in other positions, while there is a greater demand for highly qualified personnel, attracting young people to return to their hometowns and helping the construction of rural revitalisation.

As a comprehensive data platform, smart agriculture can be applied to many aspects of agricultural production, interconnection and open sharing, and a digital production management agricultural environment is coming to us.

IV. Problems and suggestions for the application of measurement and control systems

(i) Development of a clear technological shortfall

At present, most of China's wisdom agriculture greenhouse systems are introduced from abroad, the price is high, but foreign wisdom agriculture greenhouse system environment settings are not fully applicable to China's agricultural environment, making most of China's greenhouse greenhouse internal environmental parameters adjustment equipment through manual button field control, the accuracy of the acquired data is low, the system anti-interference ability is poor. Plant and animal models are too simple, the types are too few, the existing models and intelligent decision-making accuracy is low, and in many cases can not be controlled by on-demand decisions. Therefore, the development of a set of intelligent agricultural greenhouse systems suitable for the current situation of China's agricultural development is of great importance to the production and development of China's agriculture.

(ii) Low level of integration of agricultural data collection and application

Exploring the factors affecting crop growth, the occurrence and prevalence of pathogens and pests, and the factors of price fluctuations of agricultural products all require the support of a large amount of data. The quantity, systematicity and completeness of the collected data are directly related to the prediction accuracy of intelligent prediction models. Therefore, the construction of intelligent agricultural infrastructure and application systems should be strengthened, the degree of integration of agricultural information data and data standardisation should be improved, information data sharing should be sounded, and the standardisation of data collection and data collation should be promoted.

(iii) Shortage of high quality personnel

Measurement and control systems reduce the cost of irrigation labour, but they require high quality personnel who are proficient in the relevant technologies. In order to make the measurement and control system more effective and universally adaptable, in addition to the research and development of relevant technologies, the government should also speed up the training and cultivation of high-quality agricultural standardisation talents, and do a good job of cultivating a reserve of intelligent agricultural talents, cultivating young talents who understand both information technology and agricultural production. And give full play to the active role of talent to enhance the level of quality of farmers, to build a bridge for them to get rich with technology, to increase the efficiency of agriculture, bring alive the rural economy, expand the scale of production and operation at the same time optimize the mode of transport and open the sales.

(iv) Insufficient independent research and development capability

At present, most of China's wisdom agriculture greenhouse greenhouse system is introduced from abroad at a high price, but the foreign wisdom agriculture greenhouse greenhouse system environment settings are not fully applicable to China's agricultural environment. And most of China's traditional greenhouse greenhouse internal environmental parameters adjustment equipment through the manual button site control, the level of science and technology is low, making the

traditional wisdom agriculture greenhouse greenhouse system to obtain data accuracy is low, the system anti-interference ability is poor. Therefore, it is of great significance to develop a set of intelligent agricultural greenhouse system suitable for the current situation of China's agricultural development for the production and development of China's agriculture [3].

（v）Farmers' low acceptance of new technology

Influenced by backward production methods, farmers' own low quality and empiricism, most farmers have a typical mentality of being cautious and conservative. There has been a strong exclusivity to new agricultural technology, management and modern production methods. Therefore, we need to take huge advantages of the rural collective economy, use the trust of farmers in the Party branch and village committee to effectively grasp the construction of science and technology demonstration, enhance the awareness of science and technology, and launch unified training for farmers.

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V. Conclusion

The results of the Tongfu Countryside Revitalisation Demonstration Park and the Luchuan Integrated Trial Base show that the intelligent agricultural measurement and control system has great convenience and advantages in application. Firstly, the precision and timeliness of the intelligent control system control strengthens people's deep understanding of the crop growth environment, realises scientific and precise control, creates the most adaptable growth environment for plants and grows high quality and high yield green vegetables. Secondly, computer control of the shed operation on the one hand reduces the workload of the operator and improves efficiency, on the other hand, it enables the operator to monitor the whole shed situation wherever he is, realising the beneficial nature of technology.

Greenhouse greenhouse using intelligent control system is the future trend and

direction of agricultural development, it will free people from the complicated work, using the means of technology to get the most perfect results, will also help reduce costs, is the road to high quality, high efficiency, high yield agriculture.

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