



Research Status and Application of Water and Fertilizer Integrated Machine for Smart Mulberry Garden

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Abstract. The water fertilizer integrated machine is a new agricultural technology equipment used for irrigation and fertilization in agricultural planting. Unlike traditional irrigation and fertilization, the water fertilizer integrated machine controls irrigation and fertilization based on artificial intelligence technology. Scientific water fertilizer replenishment can enable mulberry trees in mulberry gardens to obtain appropriate and sufficient nutrients at all stages of the growth process. This article discusses the research of mulberry garden water fertilizer integrated machine from the aspects of mulberry garden growth and water fertilizer integration technology, and analyzes and prospects the future development trend of mulberry garden water fertilizer integrated machine.

Keywords: Water fertilizer integrated machine · Artificial intelligence technology · Smart mulberry garden · Intelligent control · Scientific replenishment

1 Introduction

Since the 21st century, China's mulberry industry has launched the "East Mulberry to West" project. Guangxi has seized the opportunity to develop the mulberry industry as a key industry, comprehensively adjusting the agricultural industrial structure, and ultimately becoming an important province to undertake the mulberry industry. However, due to the increasingly scarce agricultural labor force, the development of the silkworm industry is hindered. In response to the situation of labor shortage, the development of mechanized mulberry planting and silkworm rearing is the best solution [1]. In the modern agricultural environment, crop cultivation techniques are continuously improving, and the utilization efficiency of water and nutrients has become the main factor in increasing production, increasing income, and reducing costs. In traditional agricultural cultivation, a large amount of water and fertilizer nutrients are wasted, and a large amount of waste of fertilizer can also cause environmental pollution to the soil and surrounding environment, which is not only detrimental to the efficiency of resource utilization but also has an impact on the ecological environment [2, 3]. At the same time, the indiscriminate use of fertilizers and pesticides, as well as the destruction of soil and soil erosion,

bring great contrast to the planting and life of farmers. Therefore, scientific guidance is advocated, and artificial intelligence technology is used for analysis and evaluation to achieve real-time monitoring and reasonable allocation of soil composition and fertility analysis, irrigation water, etc. This is also a hot spot in the research of water fertilizer integration technology in recent years.

Mulberry irrigation Based on years of experience, irrigated mulberry orchards increase mulberry leaves by 37.3–40.8% annually or in the current season compared to non irrigated mulberry orchards, with an average yield of more than 20%. Therefore, reasonable irrigation of mulberry orchards is one of the main technical measures to ensure high yield and quality of mulberry leaves. Especially in the southern or arid regions where there is little rain, if mulberry gardens in the spring and summer seasons are not irrigated properly, it is impossible to fertilize the mulberry gardens, let alone obtain high-quality mulberry leaves with high yield. Mulberry is a woody plant for leaves, and fertilization should be based on nitrogen fertilizer, combined with phosphorus and potassium fertilizers. Therefore, fertilization should be applied before the spring metabolism of the mulberry is vigorous, and sufficient nitrogen fertilizer should be applied before the accumulation and storage period of the mulberry in the autumn period. On the basis of fertilizer application, fertilizer should be increased to promote the transfer of sugar from branches and leaves to the root, which is conducive to the growth and nutrient accumulation of the mulberry tree, and enhance the cold resistance of the tree [4].

The integrated technology of water and fertilizer has the advantages of saving resources and increasing production, which is conducive to the sustainable development of agricultural production and reducing the degree of soil damage. At present, China's agricultural development is facing various development issues, including the lack of large-scale and scientific agricultural production, resource shortage, and other issues, indicating that agricultural production needs reform, and the application of water and fertilizer integration technology will also become a normalization in future agricultural production [5].

This article focuses on the current situation of mulberry plantation cultivation and the demand for water and fertilizer for mulberry trees, and introduces the research on water and fertilizer integration technology in recent years. Firstly, it introduces the research status of water and fertilizer integration technology, and then combines it with water and fertilizer integration technology based on the current situation of mulberry plantation and the water and fertilizer demand of mulberry trees. Then, it analyzes the application of mulberry water and fertilizer integration machines in mulberry plantations, and discusses and analyzes various water and fertilizer integration machine control systems and fertilization methods for mulberry plantations. Finally, it discusses and analyzes the future development trend of mulberry water and fertilizer integration machines, as shown in Fig. 1.

The mulberry garden water fertilizer integrated machine studied in this article can not only improve fertilization efficiency, reduce costs and save energy while meeting the requirements for normal growth of mulberry trees, but also reduce labor costs, improve labor efficiency, increase crop yield, provide an ideal growth environment for plants, improve equipment utilization, improve greenhouse climate, reduce mulberry pests, and

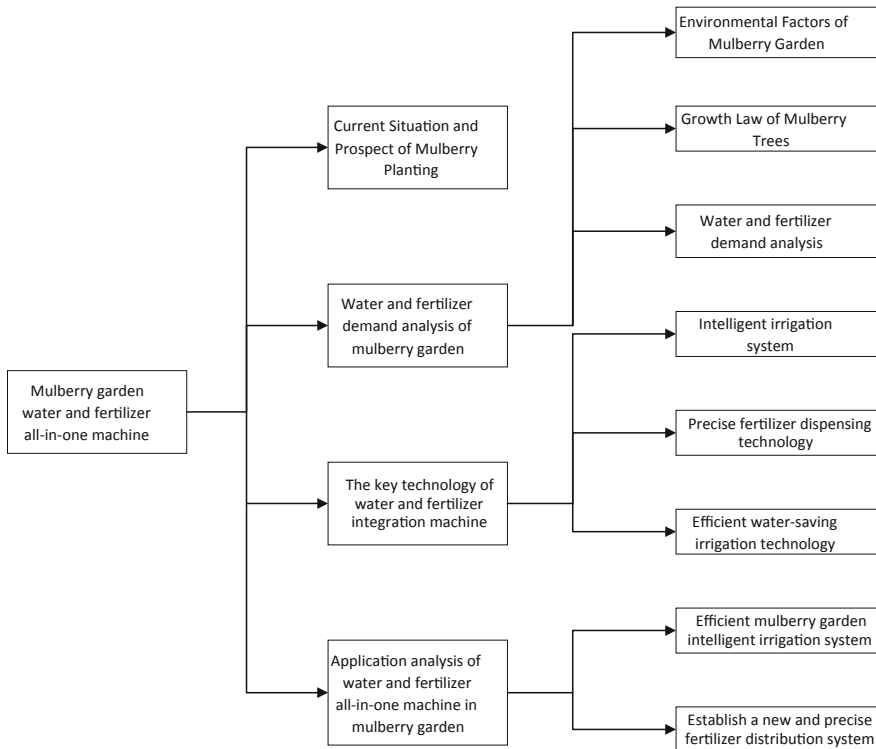


Fig. 1. Research structure diagram of mulberry garden water fertilizer integrated machine.

increase the growth rate of mulberry leaves, which has played a certain role in promoting agricultural development.

2 Current Situation and Prospect of Mulberry Planting

2.1 Current Situation of Mulberry Plantation

China is the birthplace of the silkworm industry and the world's largest producer and exporter of silk and silk. Since the reform and opening up, China has implemented the "the Belt and Road" economic strategy and jointly built the "Silk Road" economic circle and the "21st Century Maritime Silk Road", which have been endowed with Chinese characteristics in the new era. With the implementation of the "Western Development" and the industrial development strategy of "moving mulberry from the east to the west". Guangxi, which is located in the western region, has taken advantage of the above two opportunities and vigorously promoted the development of the silkworm industry. In just ten years, it has made rapid progress, taking two solid five years to take two major steps. That is, the output of mulberry cocoons at the end of the "Tenth Five Year Plan" in the first step jumped to the first place in the country, and the output of mulberry silk at the end of the "Tenth Five Year Plan" in the second step climbed to the first place in

the country, thus developing into the largest production and processing base of mulberry cocoons and silk in the country. In recent years, with the high attention of the Party committees and governments at all levels in Guangxi Zhuang Autonomous Region and the technical support of the national sericulture industry technology system project, the sericulture industry in Hechi City has achieved sustained and stable development. By the end of 2020 at the end of the “13th Five Year Plan”, the area of mulberry orchards in the city had developed to 62,100 hm², and the annual cocoon production had reached 141,300 tons. Compared to the end of the “12th Five Year Plan”, the mulberry orchards in 2015 had 53,800 hm², and the cocoon production had increased by 15.40% and 27.07%, respectively, accounting for 31.23% and 37.53% of the total area and cocoon production of mulberry orchards in Guangxi, and 7.69% and 19.44% of the total area and cocoon production of mulberry orchards in the country. Hechi City, with its mulberry garden scale and cocoon and silk processing capacity ranking first among prefecture-level cities in China for 16 consecutive years, is the largest mulberry cocoon and silk production base in Guangxi and the largest cocoon production base in China [6]. Yizhou District, located in the north-central part of Guangxi, is closely following the pace of the times, expanding its production scale, and bringing its people to prosperity. Among them, farmers planting mulberry and sericulture cover 202 villages (communities) in 16 townships and towns in the region, with 100,000 sericulture households and 456,000 people, accounting for 84.1% of the rural population. Among them, 8694 sericulture households are poor, accounting for 51.99% of the poverty households in the region. Currently, the area of mulberry gardens in Yizhou District has reached 382,000 mu, as shown in Fig. 2.



Fig. 2. Liu Sanjie silkworm industry core demonstration area, Yizhou District, Hechi City, Guangxi.

The planting mode of mulberry trees in Guangxi is basically close planting, and mainly involves sexual reproduction, namely seed sowing and seedling planting. The

main variety is Guangdong mulberry, which is densely planted in a garden. Generally, the number of trees planted per mu is between 5000 and 6000 (plant spacing: 15–20 cm, row spacing: 60–80 cm). This is significantly different from the sparse planting method of grafting mulberry with about 1000 plants per mu in Jiangsu and Zhejiang regions, Sichuan Basin, and northern regions of China, but it is based on the combination of their respective climatic conditions and the basic characteristics of mulberry varieties, using different planting methods suitable for the local area.

In recent years, although Guangxi has achieved preliminary results in the multipurpose development of mulberry resources, there are still many difficulties and problems. First, the ability to innovate in science and technology is not strong. Currently, there is a lack of specialized mulberry varieties for special purposes such as forage mulberry, medicinal mulberry, and ecological mulberry, and the supporting mulberry cultivation and management technology system for rocky desertification control, mining area reclamation, and heavy metal contaminated farmland restoration has not been established. Second, industrial development is still lagging behind. Due to the fact that the development of the mulberry industry in Guangxi has just started, the social recognition is not high, and the participation of leading industrialization enterprises in the development of mulberry resources is not sufficient, resulting in many mulberry resource products not yet entering large-scale production, especially the low technological content of the products, and the weak technological innovation ability of deep processing to improve the added value of products. The third is the shortage of capital investment and professional talents. Currently, the development of the mulberry industry has insufficient investment in basic research, construction of demonstration bases, and large-scale and high-value development of products. At the same time, there is a lack of professional and technical talents in interdisciplinary fields such as food processing, feed development, livestock and poultry breeding, and ecological and environmental protection, especially high-level top talents.

2.2 Development Prospect of Mulberry Garden

The reasons for the rapid growth of mulberry plantation scale in Guangxi are mainly driven by several factors: First, the strong government policy guidance and support. Entering the new century, the country has implemented the strategy of developing the western region, “moving mulberry trees from the east to the west”, promoting the conversion of farmland to forests, poverty alleviation, etc. The governments at all levels in Guangxi have increased their efforts to support the development of sericulture and mulberry production, and arranged special subsidy funds for planting mulberry seedlings in poverty-stricken areas. The second is that planting mulberry and raising silkworm yield fast and well. “The cash income from planting mulberry and raising silkworms has come quickly and the benefits are good. Although the prices of silkworm seedlings have fluctuated, they have generally improved, and the enthusiasm of mulberry farmers continues to rise”. The third is the strong support of improved mulberry varieties. The high-quality and high-yield hybrid mulberry varieties independently selected in Guangxi have been continuously promoted, ensuring the demand of sericulture farmers for expanding their varieties to mulberry orchards. Hybrid mulberry has a high breeding coefficient and fast growth rate. The cost of seed raising and seedling planting is low, and sericulture farmers

can achieve benefits from sericulture in the current year of planting [7]. Therefore, it is necessary to thoroughly implement the “Action Plan for the High Quality Development of the Sericulture and Silk Industry (2021–2025)”, improve the level of scientific and technological innovation, establish scientific research institutions, silkworm bases, etc., incorporate sericulture machinery into the development focus of agricultural machinery, and guide agricultural machinery research and manufacturing units to strengthen the research and development of key technical equipment around mulberry planting, mulberry garden management, mulberry leaf picking, silkworm seed production, intelligent sericulture, and other links, Develop labor-saving sericulture machinery and intelligent robots, and carry out demonstration applications.

3 Water and Fertilizer Demand Analysis of Mulberry Garden

3.1 Environmental Factors of Mulberry Garden

Mulberry is a deciduous tree or shrub, which is resistant to drought, barren soil, strong photosynthesis, good air purification effect Due to its strong soil fixation ability, sand is known as a “iron crop” [8]. Each plant has different environmental requirements. Mulberry is a deciduous tree that is suitable for growing in subtropical monsoon climate areas as a photophile, as shown in Fig. 3.



Fig. 3. Light loving mulberry trees.

The requirement of soil moisture for mulberry trees requires that the moisture content be relatively neutral. If excessive, it will cause mulberry roots to rot, making it unable to

absorb nutrients and water; If there is insufficient water, it will reduce the germination rate, and the mulberry leaves it grows will also appear withered, low water content, and poor quality. Therefore, it is necessary to detect the moisture content of the soil and supplement water or increase the concentration in a timely manner according to the situation.

The environmental temperature requirements for mulberry trees. The optimal growth temperature for mulberry trees is 20 °C. If the temperature is above 35 °C or below 10 °C, the growth of mulberry trees will be affected by printing. Therefore, it is necessary to detect the temperature of the mulberry garden environment and spray water to reduce temperature.

Mulberry trees can grow in a soil pH range of 4.5–9, but a neutral 6.5–7 growth environment is the most suitable. Soil pH is too acidic, affecting the absorption of roots, and prone to nutrient deficiencies such as phosphorus, potassium, magnesium, and calcium. Excessive alkali can lead to poor physical and chemical properties, which can easily lead to the failure of various nutrients. Mulberry trees are not easy to grow when the soil salt content exceeds 0.2%.

3.2 Growth Law of Mulberry Trees

In terms of time, mulberry trees begin to sprout in spring, and the period from the beginning of falling leaves in autumn and winter can be called the growth period of mulberry trees. During the germination stage, the leaves grow extremely rapidly, and the root system absorbs more nutrients, which also increases the need to absorb nutrients from the soil. Therefore, a large amount of fertilization is required at this time. However, due to the low temperature in spring and the slow decomposition of fertilizer, the mulberry tree cannot absorb nutrients in a timely manner. Therefore, fertilization needs to be carried out 15–20 days before the mulberry tree germinates, and fertilization must be completed one month before picking the leaves and feeding the silkworm.

In summer, due to spring silkworm rearing, mulberry trees need to undergo summer cutting after picking their leaves. Therefore, during this period, mulberry trees have entered a second rapid growth period. Moreover, in summer, the temperature is high, there is much rain, and the mulberry tree absorbs more water, so this is the most needed nutrient fertilizer.

3.3 Water and Fertilizer Demand Analysis

Soil is the foundation for the growth of mulberry trees. The content of soil nutrients directly affects the growth and development of mulberry trees. The types of fertilizer used in mulberry gardens are generally N, P, and K fertilizers, and the main organic fertilizers used are human manure, manure, and other manure. Xie Guiping et al. conducted research and diagnosis on N, P, and K fertilizers in mulberry orchards, and their soil nutrient content is shown in Table 1 [9]. The content of commonly used organic fertilizers in mulberry orchards is shown in Table 2 [9].

The amount of fertilizer applied in a mulberry garden is closely related to soil, climate, fertilizer types, and the growth status of the mulberry tree. It is generally based on the amount of nutrients required for the growth and development of the mulberry

Table 1. Nutrient content of mulberry garden soil.

Level	Organic matter (%)	Total nitrogen (%)	Hydrolyzed nitrogen (%)	Available phosphorus (%)	Abundance of nutrients
1	>4	>0.2	> 150	> 40	Ample
2	3–4	0.15–0.2	120–150	20–40	Ample
3	2–3	0.1–0.15	90–120	10–20	Ample
4	1–2	0.075–0.1	60–90	5–10	More adequate
5	0.6–1	0.05–0.075	30–60	3–5	Lack
6	<0.6	< 0.05	< 30	< 3	Less lacking

Table 2. N, P, K nutrient content of commonly used organic fertilizers in mulberry orchards.

Fertilizer name	N (%)	P (%)	K (%)	Remarks
Human feces and urine	0.5–0.8	0.13	0.21	Quick acting, slightly alkaline, can be used as base fertilizer or topdressing
Barnyard manure	0.5	0.11	0.5	Late-acting, slightly alkaline, used as base fertilizer or top dressing after rotting ripe
Silkworm excrement	0.93	0.9	0.27	Late-acting, slightly alkaline, applied after rotting is ripe
Soil miscellaneous fertilizer	0.20	0.08	0.58	Retarded, slightly alkaline, green manure composition changes greatly
Meju	6.3	0.40	0.10	Late-acting, high-efficiency, can be used as base fertilizer or top dressing
Wheat straw	5.0	0.09	0.50	Delayed effect, used as base fertilizer
Vegetation ash		1.29	8.33	Delayed and slightly alkaline, can be used as top dressing

tree. The nutrient content in the annual mulberry branch and leaf harvest, the natural fertilizer supply capacity of the soil, and the absorption and utilization rate of various fertilizers are used as the basis for determining the fertilizer amount. During the growth process of mulberry trees, they need to cut branches and pick leaves every year, which inevitably leads to the loss of a large amount of nutrients. Therefore, timely and effective supplementation of mulberry gardens can ensure the normal growth and development of mulberry trees. Fertilization in mulberry orchards is generally applied in four seasons:

spring fertilizer, summer fertilizer, autumn fertilizer, and winter fertilizer. Table 3 shows the yield and annual fertilization amount of mulberry orchards [10].

Table 3. Mulberry garden yield and annual fertilization amount.

Industrial volume (kg)	N	Urea	P	Ca(H ₂ PO ₄) ₂	K	K ₂ SO ₄
1000	15	33	6	40	8	16
1500	23	50	9	60	12	24
2000	40	87	16	107	20	40
2500	50	109	20	133	25	50
3000	60	130	24	160	30	60

Fertilization methods should be different depending on the type of fertilizer. For organic fertilizer, ditch and hole application are generally used, and it is required to be slightly away from the mulberry root system. As for ditch application, it is generally applied between rows. When applying fertilizer in a hole, it is also necessary to open the fertilizer hole between two trees and slant it between rows. Do not approach the root of the tree to avoid affecting the growth of the root system. Chemical fertilizers with high fertilizer content are generally applied in caves, located between two trees but at least 20 cm from the tree trunk [10].

4 The Key Technology of Water and Fertilizer Integration Machine

4.1 Intelligent Irrigation System

The main functions of an intelligent irrigation system are: first, to achieve intelligent control of the entire irrigation system; The second is to take water from the water source, and through the pressurization system, fertilization system, filtration system, measurement system, intelligent control system, intelligent management and Internet of Things system of the head hub, water and fertilizer will be poured into the field and transported to the root system of the crop through the transmission and distribution pipe network and irrigator; The third is to install a remote monitoring system in the mulberry garden for continuous monitoring around the clock; Fourth, real-time and dynamic observation of crop growth conditions and equipment [11].

With the wide application of computer technology, make full use of it to automatically monitor and control the agricultural environment, create a suitable crop growth environment, accurately and timely master environmental data, and predict crop growth and incidence rate of crop diseases based on real-time monitoring data to establish accurate Effective agricultural environmental monitoring and comprehensive management system has become a management technical problem to be solved in the current controllable environment agricultural production. The monitoring system designed by Lin Fengsheng et al. comprehensively uses sensor testing technology [3], RS-485 bus technology, GPRS wireless communication technology, TCP/IP network communication

technology, and effectively improves the operating performance of the intelligent irrigation system, but it does not consider the instability of the actual agricultural environment and cannot carry out precise irrigation. Bi Qianqian and other intelligent irrigation systems designed with ZigBee technology are low cost [12], simple to operate, and widely applicable, which can effectively improve the utilization rate of water resources in agricultural production, but they are only limited to the control of water flow and do not take into account fertilization concentration. The intelligent irrigation system based on NB-IoT designed by Cheng Zhangxiang and others uses NB-IoT and cloud communication to realize real-time monitoring of the irrigation site [13].

In response to the problems of rough management mode and low automation of intelligent irrigation control systems in the application of traditional water and fertilizer integration technology, Wang Xiaoli et al. developed an intelligent irrigation control system that integrates field information collection [14], remote automatic control, equipment operation status monitoring, and irrigation process regulation with modern technologies such as automatic control principles, sensors, and wireless communication technology, an irrigation decision model based on soil ET moisture was established, which effectively improved the automation of field irrigation management and improved the utilization rate of irrigation water, but did not combine the technology of precise fertilizer distribution. Qiu Yimin et al. designed an irrigation model based on image recognition and BP neural network [15], first using image recognition technology to determine whether crops are in a sick state, then using CWSI index to determine whether non-sick crops need irrigation, and finally combining the key factors affecting crop growth and BP neural network to construct an irrigation model, which has a certain accuracy for crops, but lacks research and analysis of irrigation needs of different species. Lu Xutao et al. designed a networked paddy crop precision irrigation system based on smart agricultural technology [16], and established an optimal deployment model of communication nodes, a crop water consumption prediction model, a precipitation prediction model, an optimal irrigation decision-making model, and a precise irrigation decision-making system based on fuzzy control theory. An optimal deployment method of irrigation network communication node based on the improved moth fire optimization algorithm improved by Vno Diagram is proposed, although it can be adaptively controlled by paddy irrigation equipment for precise irrigation through system decision-making, but the system relies too much on unstable weather forecast parameters, which may make the error too large and cannot achieve accurate irrigation.

At present, there are mainly several mainstream irrigation system controllers in the market: the first type uses the ST series microcontroller as the lower controller of the irrigation system. The system compares the soil moisture detected by the soil moisture sensor with the set soil moisture threshold to control the irrigation execution module. Zou Shengping et al. designed an intelligent irrigation system using the STC89C52 microcontroller as the core controller [17]. The system can collect real-time parameters such as temperature, humidity, and light intensity, with stable operation and simple operation. Liu Jun designed an intelligent irrigation system using the STM32 microcontroller as the core controller [18], achieving remote control of the irrigation process. The system can quickly respond to status and control commands, and accurately execute irrigation tasks. Lan Yu et al. designed an intelligent irrigation system based on STM32

microcontroller and raspberry pie that can intelligently detect plant species and provide scientific irrigation solutions [19]. The system can be used remotely with corresponding mobile apps, achieving the goal of scientific planting and water resource conservation. The second method is to use the Arduino microcontroller as the core controller of the irrigation system, which can play a role in automatic irrigation. Yang Zhiqin used the Arduino microcontroller as the core controller to design an intelligent irrigation system that controls irrigation based on the upper and lower limits of soil [20], and achieved automatic water renewal function of the water storage tank through a water level sensor. Fu Ning et al. designed an intelligent irrigation system using Arduino microcontroller as the core controller [21]. The system utilizes temperature sensors and soil humidity sensors to collect the temperature and humidity of crop growth, and automatically completes irrigation tasks based on crop growth habits. Sun Borui developed an intelligent irrigation system based on LSTM neural network using Raspberry Pi as the core controller [22], achieving real-time collection and monitoring of environmental data and remote control of irrigation switches. This ensures a good growth environment for crops while saving water resources.

4.2 Precise Fertilizer Dispensing Technology

If different fertilizers are simply mixed and fertilized at one time, this will directly affect the growth of mulberry trees, and excessive water and fertilizer can also cause environmental pollution issues such as soil acidification. Therefore, reasonable and accurate mixing of water and fertilizer is of paramount importance. The core lies in the precise control of EC and PH, which improves the water and fertilizer control rate and accuracy. Zhan Pan designed a fuzzy PID controller for water and fertilizer integration equipment [23], ensuring the accuracy of water and fertilizer application dosage, increasing crop yield, and saving water and fertilizer resources. Yuan Hongbo et al. studied an incremental PID fertilizer liquid regulation algorithm based on an improved Smith predictor [24]. The system has a high regulation speed and an error within the required range. Niu Yin et al. designed a mixed fertilizer control method based on variable universe fuzzy algorithm [25]. The system can better adapt to changes in formula and rotational irrigation conditions, and the control speed and accuracy have been improved. Shi Shi et al. designed an intelligent variable fertilizer allocation scheme based on fuzzy control algorithm [26], which can achieve high-precision dynamic adjustment of water and fertilizer. Wei Xianwen et al. studied the application of pH fuzzy control for water fertilizer integrated machines [27], reducing system overshoot and stability time, and improving anti-interference ability. Li Qi et al. designed a model reference adaptive conductivity regulation strategy [28], which allows the system to quickly stabilize under various disturbances and has high control accuracy. Li Qi et al. designed an accurate and intelligent control system capable of fully automatic online detection and real-time adjustment [29]. Wu Qi designed a water and fertilizer integrated control system based on particle swarm optimization and fuzzy PID algorithm [30], realizing automatic irrigation and fertilization and precise fertilizer allocation of the water and fertilizer integrated system. Wang Xiaolong designed a precise water and fertilizer ratio control system [16]. In this research method, two adjustable speed water pumps were used to respectively

absorb water and fertilizer, indirectly monitoring the concentration of water and fertilizer ratio, and achieving precise water and fertilizer ratio. In addition, the fuzzy PID control algorithm was also applied to the system. This study has certain limitations, as the error generated by the flow meter affects the concentration, Suitable EC sensors and pH sensors were not used to monitor the parameters of water fertilizer solutions. Liu Yangchun designed a variable rate fertilization mechanical device that can achieve the use of three different fertilizers [31], and based on this, developed a variable rate fertilization operation control system that can meet the needs of variable rate fertilization while meeting different fertilizers. However, this research plan has high cost and does not provide real-time monitoring of water and fertilizer concentration. A number of accurate studies make the development of water and fertilizer integrated machine have broad prospects.

In the process of transformation from traditional agricultural production mode to modern agriculture, a new technological mode has also been derived: “Internet plus” intelligent distribution technology mode. This mode is the result of the comprehensive integration of computer technology and intelligent fertilization, which fully conforms to the development trend of modern agricultural informatization. Zhang Qian elaborated and discussed the application of “Internet plus” intelligent fertilizer distribution technology model [32]. On the one hand, in order to promote the precision of fertilizer distribution by combining intelligent fertilizer distribution technology, intelligent technology and big data were introduced into the intelligent fertilizer distribution system to conduct real-time monitoring and analysis of soil water and fertilizer; On the other hand, it expands information collection and management to include crop varieties, crop cultivation, and environmental protection, making data analysis more convincing.

4.3 Efficient Water-Saving Irrigation Technology

In the current situation of water shortage, traditional water and fertilizer irrigation is no longer suitable for the development of the new mulberry industry. In the case of insufficient irrigation water, the mulberry leaves produced by mulberry trees are extremely susceptible to wilt and are not suitable for use as food for silkworm babies. Therefore, it is necessary to develop efficient water-saving irrigation technologies.

The most significant advantage of integrated water and fertilizer efficient water-saving irrigation technology is that crop irrigation and fertilization take effect quickly, and the full utilization rate of water and fertilizer is much higher than traditional water and fertilizer irrigation technology. The application of integrated water and fertilizer efficient water-saving irrigation technology can effectively avoid fertilizer application on excessively dry topsoil, resulting in problems such as volatilization loss of fertilizer nutrients and slow dissolution and absorption; In particular, it can effectively avoid the phenomenon of applying nitrogen fertilizer commonly used by fruit trees and crops to the ground, which not only saves nitrogen fertilizer, but also effectively protects the ecological environment [33]. Therefore, the integrated efficient water-saving irrigation technology of water and fertilizer has significant significance in significantly improving fertilizer utilization.

According to the relevant research by Professor Zhang Chenglin of South China Agricultural University [34], the integrated irrigation and fertilization system can save

up to 50–70% of fertilizer compared to traditional fertilization methods, effectively saving the planting cost of orchard crops; At the same time, the application of this agricultural irrigation technology has greatly reduced the water pollution and fertilizer damage caused by excessive fertilization in fruit tree planting.

The implementation of water and fertilizer integration technology in mulberry orchards has significant water and fertilizer saving effects, greatly improving the utilization rate of water and fertilizer; And can save labor; Compared to traditional flood irrigation, the integrated technology of water and fertilizer combines an appropriate amount of water and soluble fertilizer, and then delivers them to the soil near the root of the fruit tree accurately, quickly, and timely through the irrigation equipment system, reducing water evaporation and nutrient loss. Research by Lu and Wang [35], has shown that the water and fertilizer usage in apple orchards using integrated water and fertilizer technology is significantly lower than those using ordinary irrigation technology. The total irrigation and fertilization amount are significantly reduced compared to the control, with a decrease of 62.7% and 42.3%, respectively. Lu et al. [36], found that banana orchards using water and fertilizer integration technology save 49.6% water and 22.9% fertilizer compared to conventional irrigation methods. Zeng Zhi and other researchers have shown that the Shatian pomelo orchard using the integrated technology of water and fertilizer saves 395.2 yuan/mu of cost [37], 15.97% of fertilizer, and 27.73% of water compared to the conventional irrigation and fertilization orchard. Comprehensive analysis shows that the integrated technology of water and fertilizer can effectively save water and fertilizer resources, especially in areas with complex terrain, dry climate, and lack of water resources. It can save about 50% water and about 25% fertilizer.

5 Application Analysis of Water and Fertilizer All-In-One Machine in Mulberry Garden

The integrated technology of water and fertilizer is a black hole for ordinary mulberry farmers. Most mulberry farmers are unaware of new agricultural production methods and new technologies, and fail to understand their use value. Moreover, due to their relatively low educational background and lack of technical training, it is difficult to avoid encountering difficulties in the promotion process. In the process of planting mulberry, mulberry growers can only rely on their usual accumulated experience to irrigate by flooding, and are not aware of problems such as resource shortages.

Although the integrated technology of water and fertilizer has obvious advantages, it requires a large amount of funds to purchase professional equipment in the early stage, so most mulberry farmers cannot receive higher expenses. In addition, the technical development of water and fertilizer integration technology in China is not yet fully mature, coupled with large differences in local land, which cannot be fully implemented and promoted.

Due to multiple factors such as the adjustment of agricultural industrial structure and China's accession to the WTO, China's Congress has put forward higher requirements for agricultural irrigation automation technology, which indicates that the water fertilizer integrated machine will have a huge market in China. At the same time, from a long-term perspective, the integrated technology of water and fertilizer will develop towards full

functionality, simple operation, precise control, and low cost. In view of the booming trend of “precision agriculture” in recent years, the “precision control” of water and fertilizer integration has become particularly important and significant [38].

According to the current development status of water and fertilizer integration technology in China, Ma Yi discussed the development status and trend of water and fertilizer integration technology based on the development needs of agriculture in China [5]. The application area of water and fertilizer integration technology will further increase, which is an inevitable trend of agricultural development now; Water and fertilizer integration technology will also become the basic condition and inevitable requirement for the development of agricultural modernization. The national government will issue preferential policies and increase investment in technology research, making great contributions to the improvement and promotion of water and fertilizer integration, with significant results.

5.1 Efficient Water-Saving Irrigation Technology

After the above analysis, an efficient intelligent irrigation system for mulberry fields, water and fertilizer can be developed on the basis of existing intelligent irrigation systems, which can achieve precision, modernization, and informatization of mulberry gardens. The system uses ST series microcontrollers, raspberry pies, or Arduino microcontrollers as lower level controllers, servers as upper level computers, sensor technology, RS-485 bus technology, GPRS wireless communication technology TCP/IP network communication technology and other technologies are used to establish a network platform. ZigBee technology, neural network technology, and other technologies are used to improve water resource utilization. Irrigation decision-making based on soil ET moisture, image recognition, and BP neural network irrigation models are used to improve the automation of field irrigation management, achieving comprehensive and real-time management of mulberry orchard information, as well as integrated automatic control and allocation of water and fertilizer.

5.2 Efficient Mulberry Garden Intelligent Irrigation System

On the basis of the research on multiple precision fertilization techniques analyzed in Article 4.2, appropriate algorithms and controllers suitable for the mulberry garden water fertilizer integrated machine, such as fuzzy PID control algorithm and fuzzy PID controller, are selected and integrated into the control software of the water fertilizer ratio control system to achieve self adjustment during the water fertilizer ratio irrigation process and achieve the goal of water fertilizer integrated irrigation; Select appropriate EC sensors and pH sensors to monitor the parameters of water and fertilizer solutions, and improve the accuracy of the concentration of water and fertilizer solutions.

6 Summary

In summary, this article focuses on the demand for mulberry orchards and the key technologies of water and fertilizer integrated machines. Firstly, it analyzes and studies the current situation of mulberry plantation cultivation and the problems existing in the

development of mulberry orchards, mainly focusing on issues such as weak technological innovation ability and lagging industrial development. Secondly, it analyzes the water and fertilizer demand in mulberry orchards. Through reading various literature, it analyzes various methods and technologies, And it is proposed to adopt an efficient intelligent irrigation system for mulberry fields and establish a new and precise fertilizer distribution system to study the integrated machine for mulberry water and fertilizer. In recent years, there has been a large number of mature technological advancements in the research of integrated water and fertilizer technology, and the popularization of integrated water and fertilizer machines in various mulberry gardens is of utmost importance. Under the promotion of the “East Mulberry to West Movement” project in China, the integrated water and fertilizer machine in mulberry gardens has great potential for future development. Further, the flexible application of water and fertilizer integration technology in mulberry gardens can reduce the labor intensity of sericulture farmers and improve planting efficiency.

Through summary and analysis, the development trend of the integrated water and fertilizer machine in mulberry orchards is expected: the application of the integrated water and fertilizer machine in mulberry orchards will be an important research direction in the future mulberry industry, and how to more efficiently save water and fertilizer, improve the comprehensive production capacity of farmland will also be a research hotspot; Studying efficient intelligent irrigation systems and establishing new and precise fertilizer distribution systems will also be breakthroughs in maximizing agricultural benefits.

Acknowledgments. The authors are highly thankful to The College Students’ Innovative Entrepreneurial Training Plan Program for Program (No. S202210605092) for its financial support. This research was financially supported by First-class Discipline Construction Project of Hechi University, Guangxi Colleges and Universities Key Laboratory of AI and Information Processing (Hechi University), Education Department of Guangxi Zhuang Autonomous Region.

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