



Application of New Technologies for Intellectual Property Protection in Agricultural Trade in China

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Abstract

In China, the sphere of agricultural product trade is facing challenges associated with protection of intellectual property rights. Among the key issues are geographical indication infringement, disputes over rights on new plant varieties, and patent violations related to agricultural technology. Geographical indication infringement is becoming more varied and harder to detect, with e-commerce platforms increasingly being responsible for spreading fake products. New plant variety rights are frequently undermined by counterfeit goods and illegal reproduction. Meanwhile, infringement of agricultural technology patents is concentrated in such areas as smart devices and bio-pesticides. The above issues are addressed using new technologies. Thus, blockchain is instrumental in verifying the authenticity of geographical indication of products by creating an unchangeable record of their production history. DNA fingerprinting helps resolve disputes over plant variety rights by providing solid scientific evidence. Big data and artificial intelligence (AI) have made it easier to monitor and identify infringements, as demonstrated by the anti-counterfeiting model successfully applied in the West Lake Longjing. Satellite remote sensing and the Internet of Things enable comprehensive monitoring of the production process. However, the practical implementation of these technologies faces a number of difficulties. Small- and medium-sized businesses often find them unaffordable, and farmers are not always willing to adopt them. Data is stored by different departments, being fragmentary. The technologies are not always consistent with international standards. These issues can be solved by provision of governmental subsidies to optimize costs, creation of a national data platform, and promotion of international standards for technologies. In the future, in order to create a reliable, smart system for protecting agricultural intellectual property, new technologies (5G and AI) should be combined with conventional methods. This will support China's agriculture and promote its positions in the global market.

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Применение новых технологий в защите интеллектуальной собственности при торговле сельскохозяйственной продукцией в Китае

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Аннотация

Китайская сельскохозяйственная торговля сталкивается с серьезными проблемами в области защиты интеллектуальной собственности. К ним относятся такие вопросы, как нарушение прав на географические указания, споры о правах на новые сорта растений и нарушения патентов, связанных с сельскохозяйственными технологиями. Нарушения прав на географические указания становятся все более разнообразными, и их становится сложнее выявлять, при этом платформы электронной коммерции играют все большую роль в распространении поддельной продукции. Права на новые сорта растений часто подрываются контрафактной продукцией и незаконным воспроизводством. Между тем нарушение патентов на сельскохозяйственные технологии сосредоточено в таких областях, как интеллектуальные устройства и биопестициды. Для решения этих проблем используются новые технологии. Блокчейн помогает проверять подлинность продуктов с географическими указаниями, создавая неизменяемую запись о месте и способе их производства. ДНК-дактилоскопия помогает разрешать споры о правах на сорта растений, предоставляя научные доказательства. Большие данные и искусственный интеллект упростили мониторинг и выявление нарушений, как это было продемонстрировано на примере модели борьбы

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с контрафактной продукцией на Западном озере Лунцзин. Спутниковое дистанционное зондирование и Интернет вещей позволяют осуществлять полный мониторинг процесса выращивания. Однако эти технологии по-прежнему сталкиваются с реальными проблемами. Малый и средний бизнес часто считает их слишком дорогими, а фермеры не всегда готовы их внедрять. Данные также хранятся разрозненно разными ведомствами, и отсутствует согласие относительно международных стандартов. Для решения этих проблем и сокращения расходов могут помочь такие меры, как государственные субсидии, создание национальной платформы данных и продвижение международных технологических стандартов. В будущем важно сочетать новые технологии (5G и искусственный интеллект) с традиционными методами для создания надежной системы защиты интеллектуальной собственности в сельском хозяйстве. Это поможет поддерживать сельское хозяйство Китая и укрепить его позиции на мировом рынке.

Ключевые слова: сельскохозяйственная продукция, защита интеллектуальной собственности, технология блокчейн, интеллектуальный мониторинг, географическое указание

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Introduction

Research into the use of new technologies for intellectual property protection in China's agricultural trade holds both theoretical and practical significance. In China, the volume of agricultural trade has been growing rapidly during the year of 2024, with the value of the geographical indication (GI) industry surpassing 960 billion yuan (Morrison, 2019). The sphere of intellectual property rights faces pressing challenges, such as geographical indication infringement, disputes over the rights on new plant varieties, and obstacles to obtaining agricultural technology patents.

The above issues are increasingly solved through the implementation of blockchain tracking, DNA marking, and big data anal-

ysis. The EU and the USA implement blockchain systems and DNA fingerprinting methods to successfully shield intellectual property across various regions of the world (Gassmann et al., 2020). China has achieved progress in technological development; however, it still faces difficulties in establishing efficient and practically useful systems.

Previous research has demonstrated that GI frauds can be successfully prevented using blockchain tracking systems. DNA testing was shown to be a trustworthy method for solving disputes over plant variety rights, while big data analysis enhances detection of intellectual property infringement (Aronzon, 2019). However, the practical implemen-

tation of these technologies is associated with a number of problems, such as high costs and limited applicability in different regions. In order to raise their efficiency, these technologies should be used in combination with traditional protection methods, thus enabling the construction of a smarter system for intellectual property protection in the agricultural sector. Such a system will be instrumental in supporting the international competitiveness of China.

This article aims to (1) identify the main issues of intellectual property protection in the field of Chinese agricultural products, (2) reveal the risks associated with the infringement of rights to geographical indications, new plant varieties, and agricultural technologies, and (3) examine the potential of using new technologies (e.g., blockchain, DNA identification, big data, AI, satellite monitoring, and IoT) for solving the aforementioned issues. The research contributes to the development of a comprehensive intellectual property protection system to strengthen the competitiveness of Chinese agriculture in the global market.

1. Technological challenges in the protection of agricultural product intellectual property rights

1.1. Geographical indication infringement issues: counterfeiting, adulteration, e-commerce platform infringement, etc.

At present, the infringement of geographical indications (GI) is the major obstacle to intellectual property protection in the field of ag-

ricultural products in China. The rising market value of GI products has triggered an evolution of infringement patterns which are now presented as increasingly complex and disguised forms spreading across multiple regions (Li et al., 2023).

The illegal use of counterfeit methods represents a widespread infringement pattern which involves using fake packaging and fake certification marks to sell ordinary agricultural products as famous GI products. The issue of counterfeit products is clearly demonstrated by the “Wuchang Rice” case, when fake products have started to dominate the market more than genuine ones (Yu et al., 2025). The Wuchang Rice Association published alarming statistics which showed that approximately 1 out of 14 kilograms of Wuchang Rice products sold in the market represents authentic rice¹. The deceptive actions of fraudsters lead to both diminished consumer confidence and right violations while causing significant yet hard-to-measure damage to authentic GI brands.

Another significant concern is adulteration. Some unscrupulous merchants adopt a “blending” method, mixing a small quantity of genuine products with a large proportion of ordinary ones for sale. For instance, in the case of “Yangcheng Lake hairy crab”, certain vendors obtained a “Yangcheng Lake” identity certification for common hairy crabs by briefly relocating them to and breeding them in non-production areas before transporting them to the genuine Yangcheng Lake

¹ National Committee of the Chinese People's Political Consultative Conference. (2023, July 27). *Strengthening the protection of geographical indications and promoting the development of local characteristic industries*. Available at: <http://www.cppcc.gov.cn/zxww/2023/07/27/ART1690422376860119.shtml>. (In Chinese).

² Chinese Geographical Indication Products Open Up Global Markets. (2025, July 9). *China Business News*. Available at: <https://www.cfsn.cn/news/detail/33/304948.html>. (In Chinese).

region² (Zhao, Zhan, 2025). This type of adulteration is highly surreptitious, often eluding detection by conventional oversight mechanisms.

It should be noted that with the rapid advancement of e-commerce platforms, GI infringement has undergone a significant migration from conventional offline channels to the online sphere. Numerous infringing vendors populate platforms, such as Pinduoduo and Taobao, falsely purporting to offer “direct supply from the origin” or “direct sales from the original factory”. These entities cunningly exploit algorithmic vulnerabilities within platforms and leverage consumer predispositions to commit their illicit acts.

1.2. Problems related to the protection of new plant varieties

The new varieties of plants suffer a serious threat of forgery and piracy (Hou, 2019). Thus, by crossing different pools (offspring) with each of the four original bulks (parents) and using the same flanking primers, the Itaimbezinho and Saragoza parents could be hybridized in at least two different combinations, giving at least two different restriction fragments. Fake variety rights, which are obtained by slight modifications of the original variety, are well known³. Such frauds are extremely difficult to detect.

Another major issue is non-authorized multiplication. There are a number of companies or individuals involved in a large-scale spread of legitimate varieties of unauthorized

acts, causing great damage to the interests of the right holders. For example, in the “Long Liangyou” rice infringement case, the infringer illegally multiplied 17,860 kg of seeds, causing great economic losses to the variety right holder (Chunchun et al., 2022). Pattern features of such violations are highly organized with a full industry chain from farming to sales.

The existing regulatory system currently faces numerous challenges:

- underdeveloped technology for authenticity identification, with traditional field planting methods being slow and costly;
- lack of law enforcement personnel to effectively supervise dispersed seed production bases;
- insufficient punishment failing to create a sufficient deterrent for infringers.

Collectively, these issues severely impede innovation and development within the seed industry. High enforcement costs have discouraged some breeding companies from pursuing rights protection, significantly dampening their enthusiasm for innovation. A survey revealed that over 80% of high-end vegetable seeds are imported, a situation directly linked to a poor intellectual property protection in the domestic seed industry⁴.

In order to overcome these challenges, a more comprehensive protection system is needed. This system should include robust tools, such as DNA molecular fingerprint databases and remote sensing monitoring networks, to ensure protection of variety rights.

³ Zhejiang Guangsha Construction Vocational and Technical University. (2025). *The National Intellectual Property Administration released the white paper “The Status of Intellectual Property Protection in China in 2024” (Excerpt from Geographical Indications)*. Available at: https://www.guangshaxy.com/kydtlink/cyyjy/cyyjykydt/content_66727. (In Chinese).

⁴ Qiao Jinliang, Ji Leilei. (2022, April 12). *Survey on Seed Industry Issues*. Available at: https://www.moa.gov.cn/ztzl/ymsn/jjrbdd/202204/t20220413_6396277.htm. (In Chinese).

1.3. Agricultural technology patent infringement risks: Patent protection in the fields of smart agricultural equipment, biological pesticides, etc.

Agricultural technology patents serve as a major obstacle which hinders new innovations from reaching the market. In the sphere of agricultural equipment, the main infringement patterns concern technology plagiarism and product replication. Following the African market success of an “intelligent water-fertilizer integration system”, numerous cheap knock-off products appeared. This reduced drastically the sale potential of authentic products⁵. The biological pesticide industry experiences widespread patent infringement, e.g., companies may use reverse engineering to derive the fundamental technology before submitting patent applications with slight alterations. The unauthorized technological development breaks the natural progression of authentic innovation.

Protection in the sphere of agricultural technology patents faces the following challenges.

- The scattered nature of infringement in field-based agricultural applications makes it difficult to obtain proof for patent violations.
- The rapid advancement of agricultural technology clashes with the slow pace of patent reviews; as a result, the technology being patented becomes obsolete by the time it receives approval.

- The challenge of protecting agricultural technology through patents arises because the technology serves public needs but requires protection for wider distribution.

New data from 2024 shows that China holds only 5% of worldwide agricultural PCT (Patent Cooperation Treaty) international patent applications, while the United States controls 32% and the European Union maintains 28%. The inadequate patent protection system directly causes this patent protection gap between countries (Fujii, Managi, 2018).

The advent of digital agriculture introduces new intellectual property challenges in agricultural big data. While farmland, meteorological, and market data have emerged as critical assets, unclear ownership and usage regulations frequently lead to disputes. An incident where the soil database of an agricultural technology company was illegally crawled by a competitor highlights vulnerabilities in agricultural data protection⁶. Furthermore, insufficient international patent coverage leaves Chinese companies vulnerable in overseas markets. For example, an irrigation equipment company facing patent infringement in Southeast Asia was unable to defend its rights due to a lack of local patent registration (Stern, Li, 2016).

The creation of an efficient technology protection system requires addressing multiple complex problems, such as the following.

- Patent processes need acceleration through implementation of more rapid review mecha-

⁵ Ding Yanhong, Liao Qian (2025, April 3). *Focus on high-quality and efficient legal supervision and help protect cultivated land. After the irrigation system was repaired, the farmland regained vitality.* Available at: https://www.spp.gov.cn/spp/zdgz/202504/t20250403_692199.shtml. (In Chinese).

⁶ China National Intellectual Property Administration. (2025, July 9). *Beijing releases ten typical cases of data intellectual property protection.* Available at: https://www.cnipa.gov.cn/art/2025/7/9/art_57_200533.html. (In Chinese).

nisms, which can decrease the time needed for agricultural technology authorization.

- Monitoring capabilities should be improved through advanced technologies, such as real-time tracking using IoT data from devices.
- Global cooperation needs reinforcement to ensure worldwide protection of agricultural technology patents.

China can realize its significant potential in the agricultural sector only by resolving the protection bottlenecks that block the large-scale development of agricultural science and technology innovation.

2. Legal aspects of the use of new technologies in agriculture

2.1. Blockchain Technology

The use of new technologies in protecting the intellectual property rights of agricultural products has shown great success. Blockchain is instrumental in tracking the origin of products with geographical indications. DNA technology offers a knowledge-based approach to protecting plant variety rights. Big data and AI are used by authorities to enforce laws more effectively. Satellite remote sensing, along with IoT, enable real-time monitoring (Bai et al., 2023). These technological advances offer reliable support in creating an improved system for protecting intellectual property. Along with the implementation of the “2025 Intellectual Property Administrative Protection Work Plan”, the use of new technologies will be extended, giving additional strength to the protection of agricultural product intellectual property.

2.1.1. Application scenario: GI traceability

Due to the characteristics of decentralized and tamper-proof blockchain networks,

enabling detecting the origination of a specific product with geographic indications (GI), they have become the mainstream technological means for tracking the sources of goods with place names. In the tea industry, e.g., the “Anxi Tieguaoyin” agency in Fujian has created a full-track traceability flow, from tea garden to teacup, supported by blockchain. By swiping a product’s QR code, consumers can access important information such as planting plots, picking times, and processing methods. Similarly, Suzhou’s “Yangcheng Lake Hairy Crab” has a blockchain-enabled anti-counterfeit solution, with every “actual” crab associated with a unique anti-counterfeiting code. In 2024, this model facilitated the investigation and seizure of 120,000 infringing items. These types of applications increase consumer trust flow and offer an accountable platform to support administrative law enforcement⁷.

2.1.2. Advantages: tamper-proof, fully traceable, and enhanced consumer trust

Blockchain exhibits a substantial potential for the protection of intellectual property rights in agriculture. This technology provides three primary features with far-reaching implications: tamper-resistance, complete traceability, and consumer trust.

First, blockchain is practically tamper-proof, since its data structure is built on a distributed ledger system. Each block is linked to the previous block using a specific form of hash encryption. In other words, if a firmware update were made to a historical record, the consumer would be alerted and it would not have succeeded in transferring culpability back to earlier records in the chain. In a nutshell, any change to the history of the chain auto-

⁷ Yangcheng Lake hairy crab fishing season begins. (2024, September 26). *Suzhou Daily*. Available at: <https://www.suzhou.gov.cn/szsrzmzf/szyw/202409/43d13f3fff694c50b0b37d176e6a29c6.shtml>. (In Chinese).

matically alerts the system and the transfer would be instantly rejected.

Second, blockchain provides accurate traceability of agricultural products. Blockchain provides information on the entire lifecycle of the agricultural product. In contrast to a traditional database, where sensitive information can only reside in a single place, blockchain provides a universally distributed ledger that stores information “on the books” and can be balanced with every node in the supply chain. This facilitates a complete, real-time, and transparent traceability chain. In turn, this improves efficiency in agriculture bureau and regulatory procedures and provides indisputable electronic evidence for disputes regarding quality.

Third, algorithms also provide a significant boost in consumer confidence by providing “algorithmic trust”. Consumers can use their smartphones to easily verify the authenticity of the product by scanning a QR code and accessing its information including further parts of the value chain. The resulting technological improvement in traceability and transparency provides a large shift in addressing the information asymmetry of traditional agricultural product markets.

2.1.3. Example: Fujian “Zhenghe White Tea” blockchain traceability system

This technology has already been used for the purposes of protection of the Fujian Zhenghe white tea. The information is transmitted through 5G networks for fast processing as AI analytics enable predictive quality control and automatic anomaly detection. Technologically speaking, this approach ensures uploading all warehousing onto the chain and processing up to terminal sales of tea data

for every link generating an unalterable time stamp record, thus being a reliable technological assurance for product quality traceability⁸. From the perspective of industrial upgrading, the system value consists not only in anti-counterfeiting and traceability effects but, even more importantly, in the industrial value added through data assetization. It forms a unified settlement platform through which real-time transactional data collection is enabled, thereby providing support for the discovery process of a fair price index for white teas in facilitating more transparent and standardized market pricing. From the perspective of industry promotion value, this system offers a technological solution that can be copied for digital management relating to geographical indication products. When facing infringement on e-commerce channels, the data connectivity between the blockchain traceability system and the e-commerce platform is particularly important for effectively identifying fake propaganda like “direct supply from origin”, hence offering a technological weapon for online anti-counterfeiting.

2.2. DNA Molecular Fingerprinting

2.2.1. Application scenario: Protection of new plant variety rights

DNA molecular fingerprint technology has become the main technological means for protecting the rights on new plant varieties. Currently, its application scenarios have extended from single variety identification to full-chain intellectual property protection. The technology builds a “molecular ID card” for the variety using SNP (single nucleotide polymorphism) or SSR (simple sequence repeat) markers specific to the variety, thus creating a knowl-

⁸ <http://www.cppcc.gov.cn/zxww/2023/07/27/ART11690422376860119.shtml>.

edge-based foundation for infringement identification (Jamali et al., 2019). This technology was successfully applied in the “Jingke 968” corn infringement case during the Hainan Free Trade Port “Green Sword” special operation. A comparison of gene sequences of infringing seeds and those of genuine products, given that the consistency reaches 99.9%, provides key evidence for investigation and handling of cases⁹. In addition to corn, this technology is widely applied to protect staple crops, such as rice and wheat, and economic crops, such as fruit and vegetables. As technology advances, DNA fingerprinting is evolving from single-variety identification to whole-genome analysis, thus providing technological support for implementing Substantially Derived Variety (EDV) systems.

2.2.2. Advantages: Accurately identify infringing varieties and support judicial decisions

In comparison with conventional identification methods, DNA molecular fingerprint technology has the following major advantages. First, the identification cycle is significantly reduced. The traditional identification of field planting requires more than six months, whereas DNA testing can be completed within 48 h, which can significantly enhance law enforcement efficiency. Second, the accuracy of identification is high due to the use of multi-gene locus analysis, which is much greater than the accuracy of phenotypic identification. Third, the sample quantity is small, with only a few seeds or

leaves being sufficient to complete the test, which reduces the difficulty of evidence collection. These benefits make DNA molecular fingerprinting an essential basis for judicial decisions. The recent technological development has also facilitated the construction of standard systems. A unified national variety DNA molecular fingerprint public platform has been established to carry out standardized management of “one variety, one name, one standard sample, and one fingerprint”. In addition, this technology provides the opportunity of cross-border rights protection. Through the construction of an internationally recognized molecular marker database, it assists Chinese seed enterprises in protecting their rights and interests in foreign markets. With the decrease in sequencing costs and bioinformatics advancement, DNA fingerprint technology with achieve higher throughput and become more affordable.

2.2.3. Example: Hainan Free Trade Port “Green Sword” Special Operation

The Hainan Free Trade Port’s “Green Sword” special operation is a model example of DNA molecular fingerprint technology being used in the safeguarding of seed industry intellectual property rights. Based on the scientific developments of the National South Silicon Valley, Hainan has formed the nation’s first “Agricultural Plant New Variety Review Cooperation Center”. This initiative has reduced the cycle of reviewing new varieties from six to two months, thus significantly enhancing the efficiency of rights confirmation¹⁰.

⁹ State Intellectual Property Office. (2025, March 25). *National Intellectual Property Administration: 2025 Work Plan for Administrative Protection of Intellectual Property*. Available at: https://www.cta.org.cn/ldjh/202503/t20250325_55054.html. (In Chinese).

¹⁰ Hainan Sanya Yazhou Bay Science and Technology City accelerates the construction of the Intellectual Property Special Zone. (2022, April 25). *Nanhai.net*. Available at: <http://ipr.mofcom.gov.cn/article/gnxw/zfbm/zfbmdf/hainan/202204/1969920.html>. (In Chinese).

The Center applies the “molecular detection + remote sensing monitoring” technology in combination to finish 320 new variety rights reviews in the 2024 special operation, and collaborate with law enforcement organs to investigate and handle 87 seed industry infringement cases involving 120 million yuan¹¹. This case indicates that DNA molecular fingerprint technology not only addresses the issue of infringement identification, but also provides a solid technological support for the revitalization of the seed industry by establishing a full-chain protection system.

2.3. Big Data and Artificial Intelligence (AI)

2.3.1. Application scenarios: Customs infringement monitoring, e-commerce platform infringement identification

The integration of AI and big data has offered new opportunities for the protection of agricultural intellectual property. The China Customs has already implemented a new system to examine relevant data and identify problem products in a timely manner. The technology is more precise and effective than conventional manual checks. It is notable that AI technology can even excavate the temporal and spatial distribution patterns of infringements, offer decision support for the optimal deployment of law enforcement resources, and accomplish a transition from passive response to active prevention (Kumar et al., 2022).

2.3.2. Advantages: Improving law enforcement efficiency and reducing labor costs

The use of big data and AI technology has greatly enhanced the efficiency and economy

of intellectual property protection. The “Shijianbao” blockchain electronic evidence collection platform launched in the Zhejiang Province performs multiple functions, such as web-page and screen-recording evidence collection, thus providing law enforcement officers with a complete chain of evidence support. The merits of AI technology are also demonstrated in its capacity for continuous learning. The system has improved its capability in detecting new kinds of infringement. For instance, some companies use the geographical indication of “West Lake Longjing” while trying to deceive by taking advantage of the “Longjing flavor”. The system can precisely identify such cases.

2.3.3. Example: Hangzhou “West Lake Longjing” Big Data Anti-Counterfeiting Model

The Hangzhou “West Lake Longjing” big data anti-counterfeiting model is a representative application of AI technology in the safeguarding of agricultural product intellectual property rights. This model has been capable of discovering a black industry chain of 31 counterfeit online stores and 25 traffic diversion personnel through a multi-dimensional data analysis. According to the leads output by the model, the procuratorate set up a “counterfeit trademark criminal case filing supervision model”, which not only prosecuted the direct counterfeiters, but also brought the entire chain of packaging suppliers, traffic diversion personnel, etc., within the range of crackdown, thus achieving systematic breakthrough in infringement governance. This case manifests a deep integration of technological measures and judicial practice. The court completely accepted

¹¹ Ministry of Agriculture and Rural Affairs of the Peoples of China. (2024, April 3). 2024 National Seed Industry Supervision and Law Enforcement Year Activity Plan. Available at: http://www.moa.gov.cn/govpublic/nybzzi1/202404/t20240407_6453109.htm. (In Chinese)

the evidence offered by big data analysis during the trial and ultimately sentenced the principal offenders to from 4 to 7 years of imprisonment and imposed a total fine of over 8 million yuan¹². The verdict set a record for punishing geographical indication trademark infringement cases and manifested the force of judicial protection. More importantly, the technological route constituted by the model has been promoted and expanded to safeguarding other geographical indication products, including the “Anxi Tieguaanyin” and “Yangcheng Lake hairy crab”, offering replicable experience in constructing a nationwide intelligent protection network of agricultural product intellectual property rights.

2.4. Satellite Remote Sensing and the Internet of Things (IoT)

2.4.1. Application scenarios: Planting base monitoring, abnormal propagation behavior identification

The integration of satellite remote sensing technology with the Internet of Things (IoT) creates an innovative monitoring system for protecting the intellectual property rights of agricultural products (Sharma, Shivandu, 2024). Satellite remote sensing enables a better coverage than manual inspections. Thus, larger tea garden areas can be inspected to analyze the tea tree health through multispectral imaging, which detects chlorophyll content and water stress as indicators of unauthorized variety propagation. During 2024,

a satellite system identified three unauthorized propagation bases, which enabled authorities to retrieve 12 million yuan in economic damages¹³. By linking IoT sensors that monitor soil moisture with weather station data, the system can create a comprehensive “planting–environment–quality” association model to deliver valuable data for standardizing GI of products.

2.4.2. Merits: Real-time observational ability, less human intervention

The Tieguaanyin-1 satellite was developed under a partnership between the China Star Bridge Technology Co., Ltd., and the Anxi County¹⁴. This satellite utilizes cutting-edge technology to produce high-resolution images of tea plantations. In this respect, AI use allows this system to identify pesticide application, thus protecting and preserving the integrity of product quality. Remote sensing technology has demonstrated its validity by authenticating evidence collection for legal use by tea producers, while forming a standardized technological framework for all production areas of Pu'er tea and Longjing tea. In the future, the satellite networking of “Iron Guanyin No. 2” will provide enhanced observations with a greater monitoring precision down to sub-meter accuracy, thereby enabling improved protection of agricultural intellectual property rights through the entire supply chain.

2.4.3. Example: Anxi “Tieguaanyin No.1” satellite monitoring tea garden

The Anxi County together with the China Science and Technology Star Bridge launched

¹² Intellectual Property Office of Henan Province. (2025, April 30). *Jiaozuo City Procuratorate Launches Intellectual Property Publicity Week Activities*. Available at: <http://zjxx.hnpatent.gov.cn/home/detail/5/15175.shtml>. (In Chinese).

¹³ From “a leaf” to “a capital of 100 teas”: Anxi Tieguaanyin's innovative breakthrough. (2024, June 14). *China National Radio*. Available at: https://www.cnr.cn/fj/wh/20240614/t20240614_526746497.shtml. (In Chinese)

¹⁴ China Launches Tianhui-1 Remote Sensing Satellite. (2015, October 27). *GIS Resources*. Available at: <https://gisresources.com/china-launches-tianhui-1-remote-sensing-satellite>

the “Iron Guanyin No. 1” satellite as China’s first commercial remote sensing satellite, named after tea, which is aimed at protecting agricultural intellectual property rights through aerospace big data¹⁵. The satellite employs a multispectral imaging technology that allows cloud penetration for capturing high-definition tea garden images and AI algorithms that perform automatic detection of abnormal areas, including non-standard pesticide use and variety mixing. The satellite data integrates with blockchain traceability systems for additional processing. The product QR code allows the consumers to access remote sensing images of tea gardens, which strengthens their confidence in GI products. This case provides dual benefits through demonstrating the legal value of remote sensing technology in infringement evidence collection and establishing a replicable technological framework for other production areas, including Pu’er tea and Longjing tea. The upcoming network integration of “Iron Guanyin No. 2” satellite will raise monitoring precision to sub-meter levels, thus enhancing the protection of agricultural intellectual property rights along the entire chain¹⁶.

3. Challenges and optimization paths for new technology applications

3.1. Obstacles to technology promotion

3.1.1. High application costs for small- and medium-sized enterprises

The implementation of new technologies, including blockchain, DNA testing, and big data analysis, for the purposes of agricul-

tural product intellectual property protection yields outstanding outcomes. However, the high expenses associated with their deployment and maintenance represent significant barriers for small- and medium-sized enterprises. Any blockchain traceability system requires significant financial investments due to the need to develop private or alliance chains, which demand numerous hardware components, software programming tools, and ongoing maintenance expenses. The first monetary outlay for a single business may reach several hundred thousand yuan. The establishment of a DNA molecular fingerprint database demands both specialized testing instruments and expert technicians, which proves challenging for small- and medium-sized seed companies.

3.1.2. Low acceptance of new technologies by farmers

As a rule, farmers lack the required level of technological awareness and operational capacity. Although the “blockchain + vegetable” traceability platform in Weifang City, Shandong Province has greatly improved the market premium of vegetables, such as leeks (with an average rise of 9–30% per acre), some farmers continue to be reluctant to enter the system because of the complexity of use¹⁷. The same concerns the area of smart irrigation equipment. Many smaller farmers tend to rely on traditional experience instead of implementing accurate irrigation recommendations based on the Internet of Things. This technology acceptance gap has resulted

¹⁵ Anxi Tieguan Yin No. 1 satellite releases digital vitality of tea industry. (2022, March 11). *Quanzhou Evening News*. Available at: <https://www.taibo.cn/p/81135>. (In Chinese).

¹⁶ Anxi Tieguan Yin No. 1 satellite launched successfully. (2022, March 1). *Fujian Daily*. Available at: http://gxt.fujian.gov.cn/zwgk/xw/hydt/snhydt/202203/t20220301_5846709.htm. (In Chinese).

¹⁷ Ministry of Agriculture and Rural Affairs of the Peoples of China. (2024, October 17). *Typical Case Study of Digital China Construction No. 9. Innovative Application of “Blockchain + Vegetables” Quality Traceability*. Available at: https://www.moa.gov.cn/xw/bmdt/202410/t20241017_6464550.htm. (In Chinese).

in a rapid spread of new tools in large-scale planting areas but their slow advancement in decentralized management areas.

3.2. Data standards and cross-departmental collaboration issues

3.2.1. Data island phenomenon

Currently, the management of agricultural intellectual property protection in China faces the problem of severe data fragmentation. The Ministry of Agriculture and Rural Affairs, the National Intellectual Property Administration, the State Administration for Market Regulation, and other departments have organized independent data systems, which are lacking unified data standards and interface specifications. Taking the management of GI products as an example, the agricultural product geographical indication (AGI) of the Ministry of Agriculture and Rural Affairs and the geographical indication protection products (PGI) of the National Intellectual Property Administration adopt different application procedures and testing standards, which demands enterprises to submit materials repeatedly, which raises the related administrative costs. Such data fragmentation not only decreases the efficiency of administration, but also influences the effectiveness of supervision. The 2024 Hangzhou “West Lake Longjing” anti-counterfeiting case indicates that the inability of various departments to share data in real time hindered the process of discovering and preventing infringements by regulatory authorities in a timely manner. This data island phenomenon has become a major bottleneck constraining the effectiveness of agricultural intellectual property protection.

3.2.2. Technological collaboration bottleneck

Cross-departmental data sharing faces both technological and institutional obsta-

cles. On the technological level, the blockchain traceability systems built in various places lack compatibility with national databases. As a result, companies need to manually re-enter data, which increases their operational costs. On the institutional level, various departments have concerns about data sovereignty, in particular, sensitive DNA data on new plant varieties involving breeding secrets. However, scientific research institutions are often reluctant to share such information. The practice of the Hainan Free Trade Port shows that the establishment of a sharing mechanism where “original data does not leave the domain and is available but not visible” can ensure effective collaboration under the premise of protecting data security.

3.3. International standard compatibility

China has achieved significant progress in technological innovation in the field of intellectual property protection for agricultural products. At the same time, the compatibility with international standards remains to be an acute problem. The example of the Regional Comprehensive Economic Partnership (RCEP) framework shows that, although the China–EU Geographical Indications Agreement has successfully promoted 100 Chinese GI products to obtain EU protection, the recognition of China’s technical solutions is still limited in RCEP member countries, such as the Association of South-east Asian Nations (ASEAN). The main obstacles are the existing differences in standardization systems and inconsistency of testing methods. For example, China’s blockchain traceability standards are not included in the Codex Alimentarius Commission (CAC) system, resulting in the need to pay additional third-party certification fees when

exporting “Wuchang Rice” to Southeast Asia. Similarly, the results of DNA testing technology are frequently questioned during cases of cross-border rights protection due to different molecular marker sites used by different countries (e.g., China uses SNP while Japan prefers SSR)¹⁸.

4. Results

4.1. Governmental subsidies to reduce the costs of technology application

The promotion of modern technologies in the field of agricultural intellectual property protection faces the problem of a structural cost–benefit imbalance (Ren et al., 2017). From the economic perspective, new technologies may yield significant positive effects, although requiring hard-to-cover investments of an individual enterprise, thus weakening its competitive position. The government should introduce the policy of subsidies by accurately recognizing the marginal cost curves of enterprises of various sizes and developing differentiated incentive mechanisms. Thus, for startup technology firms, R&D subsidies are necessary to mitigate innovation risks. For application-oriented small- and medium-sized enterprises, a composite model of “basic module subsidies + value-added service self-payment” appears more appropriate. The design of a subsidy policy should avoid the two extremes of “sprinkling pepper” and “raising lazy people”. Instead, it should introduce a “step exit” mechanism to gradually decline the subsidy proportion along with the growth of enterprises and their technological maturity. Meanwhile, tax incentives

should be aimed at guiding enterprises to shape a virtuous cycle of continuous innovation investment, rather than a straightforward one-time reduction or exemption.

4.2. Need to establish a national unified agricultural intellectual property data platform

The scattered management of agricultural intellectual property data is a manifestation of disproportionately high institutional transaction costs. The fundamental value of constructing a unified data platform consists in eliminating the loss of efficiency due to information asymmetry. From the standpoint of institutional economics, this involves the reconstruction of the three levels of property rights definition, transaction rules, and governance structure. First, the ownership of data elements should be clarified, and the boundaries of rights and obligations of public data, enterprise data, and farmer data be demarcated. Second, standardized data transaction rules should be established, including interface protocols, security specifications, and revenue distribution mechanisms. Third, a multi-center collaborative governance structure should be designed to balance relations between central coordination and local autonomy. The platform construction must adhere to the principle of “minimum necessity”, with a focus on breaking through data bottlenecks in key business scenarios instead of seeking big and comprehensive data agglomeration. Particular attention must be given to preventing data monopoly risks and avoiding the emergence of a new digital divide.

¹⁸ Genetic Testing and International Regulation: Safety and Ethical Issues. (2024, November 13). *HIRO Clinic*. Available at: <https://www.hiro-clinic.or.jp/gene/genetic-testing-regulations-ethics/?lang=zh-hans>. (In Chinese).

4.3. Need to promote international standardization of blockchain, DNA testing, and other technologies

The international competition of technological standards is a competition for the right to “speak” in the industry. To realize the transformation from “following” to “leading” in the technological field of agricultural intellectual property protection, China should overcome the path dependence in standard setting. From the point of view of innovation theory, the interactive relationship of “technology–standard–market” should be re-examined. On the one hand, this requires promotion of the continuous input of basic research and establishment of independent intellectual property rights in the underlying areas, such as blockchain consensus algorithm and molecular marker technology. On the other hand, China should actively participate in the governance reform of international standardization organizations and promote the establishment of a more inclusive and diversified standard setting mechanism. In terms of specific strategies, the principle of “focusing on breakthroughs and taking points to lead the whole” should be adhered, selecting subdivided fields with comparative advantages to achieve breakthroughs first, and then gradually extending China’s influence. Meanwhile, China should concentrate on training compound international standard talents and increase its discourse capacity in global technology governance.

Conclusion

The implementation of new technologies in the field of protection of intellectual property rights in China’s agricultural product trade has proved successful. As an incorruptible ledger, blockchain technology has greatly reduced the infringement of geographical indication products. DNA molecular fingerprint technology provides scientific evidence

to resolve the disputes over new plant variety rights. Big data and artificial intelligence have significantly improved the identification of infringement and enforcement decisiveness. Satellite remote sensing and the Internet of Things are used to accurately monitor the entire agricultural production process. However, in China, the promotion of such technologies is currently facing a number of obstacles, such as the high cost of their application by small- and medium-sized enterprises, their limited recognition by farmers, data inconsistency between various departments, and insufficient activities to comply with international standards. The need to create a multi-level optimization path to solve these problems is evident. This requires reducing the threshold for technology application through governmental grants, constructing a national unified agricultural intellectual property data platform to overcome information isolation, and take an active role in the exquisite drafting of international standards to improve the global compatibility of technological solutions. In theoretical terms, the protection of intellectual property rights in agricultural production has evolved into a new “technology–system–market” paradigm of coordinated development. In practical terms, a deeper integration of technological and institutional innovations is required. The future development direction should focus on the following priorities: the development of lightweight technological solutions that would meet the needs of small- and medium-sized farmers; the design of a cross-departmental, cross-regional collaboration and supervision mechanism; a deeper involvement in the construction of a global agricultural intellectual property governance system. By means of employing and commercializing cutting-edge technologies of more mature 5G and quantum computing, the protection of intellectual property rights of agricultural

products will enter a new stage of intelligence and precision. This will contribute to enhancing the system of agricultural intellectual property protection in China, supporting the international competitiveness of Chinese agricultural products and, ultimately, fulfilling the strategic aim of high-quality agricultural development and rural revitalization.

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