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The Exhaustion Doctrine in the Seed Sector: Application Dilemmas and Institutional Reconstruction — Biological Characteristics, Legal Conflicts,and Institutional Responses

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Abstract. Due to their biological replicability, seeds pose a significant challenge to the traditional principle of exhaustion of rights, giving rise to issues of territorial conflicts and regulatory gaps in global seed trade. In response, states must establish a system of limited exhaustion rules centered on the control of reproductive rights, constructing a special institutional framework that balances incentives for innovation, public interest, and international coordination. At present, China faces problems in this domain, including legislative ambiguity, insufficient judicial discretion, and weak international coordination. Considering the impact of seeds' dual "product–production tool" attribute on the theoretical basis of exhaustion of rights, as well as the intrinsic mechanism by which they disrupt the "economic reward theory" and the "implied license" theory—thereby creating systemic dilemmas—a three-dimensional pathway should be developed with "limited exhaustion of rights" at its core: legislatively, by establishing exceptions for "reproductive behavior control rights"; judicially, by creating a "three-step analytical" adjudication framework; and internationally, by promoting the formulation of special and differentiated exhaustion clauses and bilateral recognition mechanisms.

Keywords: seeds, new plant varieties, exhaustion of rights principle, territorial conflicts

1. Introduction

The principle of exhaustion of rights holds that once the owner of intellectual property—or their authorized party—has lawfully placed a product on the market, the owner's partial or full exclusive rights are terminated, and further use or sale of that product by others does not constitute infringement [1]. As an important limiting rule, the principle of exhaustion of rights has already been reflected and applied in China through specific judicial practices and certain statutory provisions. However, seeds, due to their self-replicating nature as biologically active materials, present significant particularities that make the general exhaustion principle inapplicable. Existing research on the theory of exhaustion has largely focused on industrial products. Although domestic studies have noted territorial conflicts in the protection of new plant varieties, there remains a lack of systematic deconstruction of exhaustion rules, particularly analyses that cross-examine the dual "biological–legal" nature of intellectual property in the seed sector.

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Amid the trend of increasing liberalization in global seed trade, the determination of exhaustion in the seed sector has gradually evolved into a challenging issue in international intellectual property governance. Multinational seed enterprises in developed countries control a large portion of the global commercial seed supply chain through patent portfolios, while developing countries' demand for imported germplasm continues to rise. Against this backdrop, the territorial characteristics of seed patents sharply conflict with the globalization demands of international trade: when rights holders assert the territoriality principle of patents to restrict parallel imports, developing countries claim the applicability of international exhaustion based on food security considerations. As the world's second-largest seed market, China faces the urgent institutional challenge of balancing germplasm importation, domestic seed innovation, and food security.

2. The dilemma of applying the principle of exhaustion of rights in the seed sector

The inapplicability of the general exhaustion of rights principle in the seed sector fundamentally stems from the conflict between seeds' self-replicating property and the legal foundation of the exhaustion principle.

2.1. Legal foundation of the principle of exhaustion of rights

The deeper legal basis of the exhaustion of rights principle lies primarily in a mechanism of interest balancing: to prevent monopolistic rights from becoming obstacles to social progress and development, intellectual property systems, while safeguarding creators' exclusive rights, impose necessary limitations to coordinate the interests of creators, disseminators, and users [2]. According to the "economic reward theory," the intellectual property owner has obtained sufficient economic compensation to incentivize innovation through the initial sale of their knowledge product; therefore, their control over subsequent copies of that specific product should be exhausted, and they should not claim rights over the same product again to obtain double or multiple remuneration [3]. Similarly, the "implied license" theory holds that when an intellectual property owner places a protected product on the market without attaching any explicit restrictive conditions, a reasonable purchaser would understand that the price paid not only purchases the physical "thing" itself but also includes the right to freely use, resell, or otherwise dispose of the product.

2.2. Conflict between seeds' biological attributes and the legal basis of exhaustion

Unlike ordinary commodities, seeds possess a self-replicating characteristic: their use generally produces new plants and ultimately generates new seeds. Seeds can serve both as harvest material and as reproductive material. Consequently, a seed can function as both a "product" and a "production tool," depending on the context of use. If the general exhaustion principle were applied in this sector, anyone could cultivate a large quantity of seeds with the same or similar traits as the original variety after a single purchase and sell them in the market just like the rights holder. Over time, the exclusive rights held by the owner in seed patents, plant variety rights, and other intellectual property would be substantially diminished, directly conflicting with the interest-balancing mechanism underlying the exhaustion principle.

From the perspective of the economic reward theory, this theory assumes that after the initial sale, the rights holder has already received sufficient incentive through that transaction. However, the core value of seeds as "production tools" lies not in the material object sold, but in the genetic information they carry, which can continuously replicate itself to produce subsequent generations.

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By planting seeds, purchasers do not merely "use" the product; they activate its "production function," creating new reproductive material with identical commercial value. This creates a significant asymmetry: the one-time sale cannot provide the rights holder with compensation for the continuous use of their core technology (genetic traits). Applying the traditional exhaustion principle would effectively allow purchasers to acquire a perpetual "production technology" for the price of a single product, substantially eroding the rights holder's economic return and fundamentally weakening the incentive for innovation.

From the perspective of implied license theory, this theory presumes that purchasers acquire the freedom to dispose of the specific product under ordinary transaction conditions. Yet the "production tool" nature of seeds blurs the line between "use" and "replication." Would a reasonable purchaser interpret the price of one seed as granting the right to mass-produce and sell countless descendants? The answer is clearly no. Social cognition and commercial practice do not support such an interpretation. The biological property of self-replication prevents the initial sale from being reasonably understood as an implied authorization for unlimited, uncompensated exploitation of the rights holder's core technological innovation.

Moreover, under the "functionality doctrine," when a functional element exists in a protected object in an "inseparable" or "substantially controlling" manner, the scope of intellectual property protection should be dynamically limited to prevent substantive monopolization. In the context of this study, purchasers cannot rely on the exhaustion principle to reproduce plant varieties protected by intellectual property laws.

The classic U.S. patent litigation case Bowman v. Monsanto Co. exemplifies the inapplicability of the general exhaustion principle due to seeds' unique attributes. Monsanto held patents on glyphosate-resistant genetically modified soybean seeds and explicitly restricted farmers through licensing agreements to plant the purchased seeds only for the current season. Nevertheless, farmer Bowman purchased commodity soybeans labeled "for food use" from local grain elevators, planted them, and saved seeds from herbicide-resistant plants for subsequent planting over eight years without paying patent royalties. Upon discovering Bowman's actions, Monsanto filed a patent infringement lawsuit; Bowman raised an exhaustion defense. The court held that although Monsanto's patent rights on the seeds as sold were exhausted, the second-generation seeds naturally contained Monsanto's gene, and planting them still constituted infringement. In other words, even if the exhaustion principle applied to the purchased seeds, it did not authorize Bowman to produce new seeds containing the same gene. Unlicensed planting of such seeds constituted patent infringement. On May 13, 2013, the U.S. Supreme Court affirmed that Bowman had infringed Monsanto's patent.

3. Challenges facing China

Although the self-replicating nature of seeds conflicts with the traditional legal foundation of the exhaustion of rights principle, it remains necessary to establish a special exhaustion framework in the seed sector to balance the interests of creators, disseminators, and users, maintain market order, and prevent monopolization by seed companies. However, China faces significant challenges both in constructing domestic institutions and in coordinating with international rules.

3.1. Gaps in domestic legislation

At present, China lacks legislation specifically addressing the exhaustion of rights in the seed sector.

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Take the Seed Law as an example. The current 2022 version of the Seed Law (effective March 1, 2022) focuses primarily on expanding the protection of new plant varieties, establishing a substantive derived variety system, and regulating farmers' rights to save and reuse seeds. However, it does not explicitly address the principle of exhaustion of rights. Specifically, Article 28 grants variety rights holders exclusive rights over production, reproduction, and sales, but does not regulate rights after the initial sale. Article 29 retains exemption provisions for farmers' self-propagation and use but does not cover the resale of legally circulated seeds.

Another key legal document related to intellectual property protection in the seed sector is the Regulations on the Protection of New Plant Varieties of the People's Republic of China. This regulation similarly does not provide a direct or explicit definition of the exhaustion principle [4].

It should be noted that Article 75, paragraph 1 of the Patent Law clearly establishes the principle of patent exhaustion: products obtained directly through a patented method, once sold by the patent holder or their licensee, may be used, offered for sale, sold, or imported without constituting patent infringement [5]. However, this provision is difficult to apply effectively in the seed sector. Article 25 of China's Patent Law explicitly excludes plant varieties from patentable subject matter, granting patent protection only to non-biological methods of producing plants. Consequently, seeds protected by method patents face a unique legal dilemma: on one hand, as products "directly obtained according to a patented method," they theoretically fall under the exhaustion provision of Article 75; on the other hand, the self-replicating nature of seeds inherently involves "manufacturing" new products—each planting and harvest effectively reproduces new reproductive material using the patented method, exceeding the traditional scope of "use" under the exhaustion principle and constituting a reimplementation of the method patent. This intrinsic conflict between legal status and biological characteristics underscores the need for dedicated legislation.

The lack of legislation results in ambiguity in the practical determination of exhaustion in the seed sector. While current judicial practice in China can recognize the exhaustion principle through case law, application standards are inconsistent, highlighting the urgent need for statutory clarification.

3.2. Ambiguity in judicial interpretation

China supports limited international exhaustion. However, to date, the state has not issued clear judicial interpretations. For plant variety rights in the seed sector, no equivalent explicit provisions exist [6].

The Supreme People's Court issued the Several Provisions on the Application of Law in Adjudicating Plant Variety Rights Dispute Cases (II) in 2021 (hereinafter the Provisions), which addresses the exhaustion principle, but only at a general level, lacking detailed guidance on recognition standards, scope of application, and other key issues [7]. For instance, Article 13 states: "If the sale of the accused infringing variety's reproductive material was made without knowledge and should not reasonably have been known to be unauthorized by the variety rights holder, and evidence demonstrates legal origin, the People's Court may refrain from ordering the seller to compensate, but shall order the cessation of sales and require the seller to bear reasonable expenses incurred by the rights holder to stop infringement." The Provisions do not clarify how to determine "legal origin," and this clause primarily provides an exemption for innocent infringers rather than a positive definition of the exhaustion principle, reflecting legislative avoidance of the issue.

DOI: 10.54254/2753-7048/2025.LD30500

3.3. Difficulties in coordinating international rules

Coordination of international rules on seed exhaustion faces multiple challenges, stemming mainly from fragmented treaty frameworks, divergent interests between developed and developing countries, and regulatory lag in response to rapid biotechnological advances.

The fundamental divergence between the North and South on exhaustion creates deeper obstacles to coordination. Developed countries, emphasizing innovation incentives, advocate strong protection of rights and generally oppose international exhaustion in the seed sector. Developing countries, prioritizing food sovereignty, favor more permissive rules. This value conflict continues to intensify in multilateral forums such as the WTO, but deadlocks in negotiation mechanisms make substantive compromise difficult in the short term.

Overlapping jurisdiction among international organizations further hinders effective coordination. WTO, UPOV, FAO, and other bodies intervene in seed rulemaking from trade, intellectual property, and agricultural perspectives, yet lack a formalized collaboration platform, resulting in mixed policy signals. This persistent coordination dilemma imposes high compliance costs on Chinese enterprises engaged in international seed trade: they must avoid infringement risks in countries with strict protection while preventing technology leakage through overly permissive regimes. Resolving this dilemma requires innovative international coordination mechanisms.

4. Mechanisms of territorial conflicts in seed sector exhaustion

Although countries have successively legislated to limit the scope of exhaustion in the seed sector, significant divergences and conflicts remain in practice. These differences manifest in the scope of seed-saving rights, the territorial limits of exhaustion, and the standards for asserting a “legitimate source” defense.

4.1. Gaps and fragmentation in international treaties

The primary international treaties relevant to intellectual property protection in the seed sector are the TRIPS Agreement and the UPOV Convention, of which China is a member. The current international treaty framework exhibits clear gaps and fragmented rules regarding exhaustion in the seed sector.

The TRIPS Agreement establishes minimum standards for intellectual property protection but explicitly excludes the issue of exhaustion from its dispute settlement mechanism, creating a substantive regulatory vacuum [8]. The UPOV Convention, which specifically regulates the protection of new plant varieties, shows notable differences between its texts: the 1978 Act is silent on exhaustion, while the 1991 Act allows retention of rights over reproductive material but does not provide detailed rules on exhaustion in international trade. This incremental revision has increased uncertainty in rule application. Moreover, countries differ sharply in their adoption of the texts: major breeding and innovation powers such as the U.S. and EU members generally adopt the 1991 high-standard text, whereas developing countries, including China and India, have ratified only the 1978 text [9]. This “one convention, two systems” scenario generates conflicting legal claims in cross-border seed trade.

4.2. Differences in the scope of exhaustion

The absence and fragmentation of international rules directly result in divergent national practices regarding the scope of exhaustion.

DOI: 10.54254/2753-7048/2025.LD30500

Internationally, exhaustion can be categorized into three models: international exhaustion, regional exhaustion, and national exhaustion. Countries adopt different models based on their industrial development level and position in international trade.

China's mainstream view and judicial practice tend to support the international exhaustion principle, meaning that once an intellectual property product is sold with the rights holder's consent, the rights are exhausted globally. In the case A-Mon Limited Liability Company v. Hao-Mon Technology Co., et al., the circulation of chips and software involved cross-border transactions (from foreign A-Mon to domestic Hao-Mon), yet the Supreme People's Court did not deny exhaustion simply because the initial sale occurred abroad, effectively recognizing the principle of international exhaustion. The judgment explicitly stated: "After A-Mon sold AMN chips and copies of MAC software to De-Mon Company, the economic value of these copies had been realized, and A-Mon has no right to interfere with their subsequent free circulation in the market."

In contrast, the EU applies a regional exhaustion principle: under Articles 34–36 of the Treaty on the Functioning of the European Union (TFEU), products legally placed on the market in any EU member state are exhausted only within the EU. The EU's regional exhaustion principle primarily serves the strategic goal of its single market, which aims to eliminate trade barriers between member states and facilitate the free movement of goods, services, capital, and labor [10]. The EU maintains that applying international exhaustion—where rights are exhausted upon legal sale in any jurisdiction worldwide—could allow low-priced non-EU products to enter the EU via parallel imports, disrupting internal pricing and competition. Moreover, international exhaustion conflicts with the EU's principle of legal autonomy, as the EU emphasizes the independence of its legal order and is unwilling to let international markets or foreign laws dictate its exhaustion standards.

The U.S. presents a distinctive approach that transcends these simple categories. Through the "conditional sale doctrine" and case law, U.S. courts have established a limited or conditional exhaustion framework under patent law. Although the exhaustion principle emerged in the 19th century in Adams v. Burke, the Federal Circuit in Mallinckrodt, Inc. v. Medipart, Inc. clarified that if a patent holder sells a patented product subject to explicit and lawful restrictions (e.g., single-use seeds or prohibition on saving seeds) that do not constitute patent misuse or violate antitrust law, such conditions are enforceable. Buyers violating the conditions may be liable for patent infringement. Consequently, seed exhaustion in U.S. law reflects a unique "limited" or "conditional" exhaustion: whether for domestic or international trade, if a sale includes effective restrictions, patent rights are not exhausted upon first sale, and the patent holder may assert rights against unauthorized saving, reproduction, or resale.

These differences create specific legal conflicts in the seed sector. When Chinese importers parallel-import seeds legally sold in Europe based on the principle of international exhaustion, they may face infringement claims from EU rights holders under regional exhaustion. Similarly, seeds exported from China may encounter "rights reactivation" risks in countries applying national exhaustion. At a deeper level, developed countries seek to maintain technological advantage and market control by restricting the scope of exhaustion, whereas developing countries aim to expand exhaustion to access reasonably priced seed resources. This conflict of interests impedes international coordination [11]. China must uphold the international exhaustion principle while gradually bridging differences through bilateral agreements and free trade negotiations, and clarify the specific conditions for international exhaustion in the implementing rules of the Seed Law to provide predictable legal guidance for domestic seed enterprises.

DOI: 10.54254/2753-7048/2025.LD30500

4.3. Differences in protection models

Countries also differ significantly in their protection models for new plant varieties, including seeds.

China adopts a "separation model" for protecting plant varieties, including seeds. Under Article 25 of the Patent Law of the People's Republic of China, "animal and plant varieties shall not be granted patents. Seeds are excluded from patent protection; only non-biological methods for producing plant varieties (e.g., gene editing, microbiological techniques) may be patented" [12]. In contrast, the U.S. adopts a "composite model," distinguishing between "plant patents," "plant variety protection," and "utility patents." The EU employs a dual-track system in which patent rights and plant variety rights are complementary and non-overlapping [13].

These differences in protection models complicate the determination of exhaustion in international seed trade. Different countries adopt varying intellectual property protection regimes for seeds, creating structural obstacles in trade. The gap between the separation model and the composite/dual-track models means that, in parallel imports, the importing country (e.g., China) may recognize exhaustion of plant variety rights, whereas the exporting country (e.g., the U.S.) may still claim unexhausted patent rights and initiate litigation, leading to conflicts in jurisdiction and applicable law. For the same seed, exhaustion may involve only plant variety rights in China, but in countries permitting seed patents, both patent rights and plant variety rights may be implicated. Consequently, the circulation of the same seed in international trade faces complex challenges in determining the scope and application of exhaustion.

5. Institutional optimization strategies: constructing a multi-dimensional pathway

5.1. Rule reshaping: improving domestic legislation

The legislative gap regarding exhaustion in China's seed sector has become a key bottleneck constraining the modernization of seed industry governance. It is recommended that the Seed Law be revised to include specific exhaustion provisions, clearly defining its scope of application.

One potential formulation could state: "The rights of plant variety owners do not extend to reproductive material of seeds marketed by the rights holder or with their consent; however, the rights holder retains control over further propagation activities." This design would acknowledge the basic applicability of the exhaustion principle while preserving a "propagation exception" to protect the unique interests of rights holders arising from the self-replicating nature of seeds. Complementary implementing regulations should refine standards for determining "legitimate source," for instance, by requiring sellers to provide complete supply chain documentation (import quarantine certificates, initial sales contracts with the rights holder, etc.) to balance rights protection with market efficiency.

Legislation should also address the conflict between farmers' seed-saving rights and intellectual property protection [14]. A differentiated exhaustion rule is advisable: smallholder farmers could be permitted to propagate seeds for personal use but prohibited from commercial sale, whereas large-scale producers would face limited exhaustion, requiring them to enter into technology-use agreements.

Finally, domestic legislation must dynamically interface with international trade rules. China could establish a "cross-protection declaration system" for patents and plant variety rights, requiring multinational seed enterprises to specify the dominant type of right when seeking protection in China, thereby avoiding confusion in exhaustion determinations caused by overlapping protections.

DOI: 10.54254/2753-7048/2025.LD30500

5.2. Judicial strengthening: unifying adjudication standards

Building on improved legislation, courts can fill gaps through case guidance and judicial interpretation. It is proposed that the Supreme People's Court publish model cases on seed exhaustion and establish a "three-step analysis" adjudication framework: First, examine the legality of the seed circulation chain, focusing on whether the initial sale was authorized by the rights holder; Second, assess the nature of the use, distinguishing between "planting" and the intent to "propagate"; Third, balance public interest, for example, reconciling farmers' livelihoods with incentives for seed industry innovation. This framework would reduce inconsistent rulings caused by excessive discretion at lower courts [15].

In addition, technical fact-finding mechanisms should be strengthened. It is recommended to establish a "Seed Technology Officer" role within intellectual property courts, staffed by experts with combined backgrounds in agronomy and law, to assist judges in interpreting genetic test reports, planting records, and other technical evidence. Furthermore, the use of "expert assistants" should be promoted, allowing agricultural cooperatives and seed industry associations to provide opinions on industry practices, preventing judgments from being divorced from reality.

Judicial practice should also interact with international rules. In cases involving UPOV member countries, courts may reference interpretative documents (e.g., UPOV/INF/12) on the "reasonable scope of seed-saving," but must translate such standards into domestic legal reasoning under Article 10 of the Law on the Application of Law to Foreign-Related Civil Relations, thereby preserving judicial sovereignty. For multinational enterprises exploiting territorial differences through "forum shopping," courts could issue injunctions to safeguard jurisdiction and incorporate international licensing fee comparisons in damages calculations, preventing rights holders from obtaining undue gains.

5.3. International collaboration: proactive participation in rulemaking

Given the gaps and fragmentation in international treaties, China should actively engage in global governance of seed intellectual property. In the short term, China could collaborate with groups of developing countries, such as the African Group, to submit proposals in the WTO TRIPS Council for "special and differentiated treatment of seed exhaustion," seeking to extend the interpretation of Article 30 of the TRIPS Agreement (exceptions) to the seed sector, thereby allowing developing countries to apply the international exhaustion principle to food crop seeds [16]. Within the UPOV framework, China could lead the development of a "model clause on plant variety rights exhaustion," proposing progressive rules linking the territorial scope of exhaustion to the development level of member states, mitigating the excessive restrictions on seed-saving rights in the 1991 text.

In the medium to long term, bilateral and regional coordination mechanisms could be established. On one hand, through the Belt and Road seed cooperation platform, China could conclude "Seed Intellectual Property Mutual Recognition Agreements" with Southeast and Central Asian countries, mutually recognizing exhaustion effects and simplifying cross-border seed circulation. On the other hand, it is recommended to establish a "BRICS Seed Intellectual Property Fund" to support research on exhaustion disputes in joint breeding projects, helping to form a unified stance among developing countries.

DOI: 10.54254/2753-7048/2025.LD30500

6. Conclusion and outlook

This study provides a systematic analysis of the exhaustion principle in the seed sector, revealing the institutional dilemmas that arise when this principle is applied to subjects with self-replicating biological characteristics. The findings indicate that the dual "product–production tool" nature of seeds fundamentally undermines the philosophical foundations on which traditional exhaustion theories are built. Whether based on the "economic return" rationale or the "implied license" rationale, conventional legal doctrines cannot fully accommodate seeds, which can self-replicate while functioning simultaneously as both a product and a production tool. This highlights the need for structural adjustment of existing rights boundaries and limitation rules within the intellectual property framework when the protected subject matter shifts from inanimate industrial goods to living biological materials, in order to rebalance innovation incentives, market circulation, and public interest protection.

The study situates the exhaustion issue in seeds within the broader context of global seed governance and North–South interest dynamics, systematically illustrating the mechanisms underlying territorial conflicts and identifying China's practical challenges in terms of ambiguous legislation, insufficient judicial basis, and weak coordination of international rules. In doing so, it partially fills a gap in domestic scholarship by offering a systematic deconstruction of plant variety rights exhaustion rules, providing theoretical support for the construction of a legal framework that reconciles domestic seed innovation with food security concerns.

However, the research primarily relies on normative analysis and case studies and lacks empirical data on market participants' behavior across the seed supply chain, which may limit the conclusions' reflection of practical complexity. In addition, the study focuses on plant variety rights, leaving the exploration of composite exhaustion issues arising from overlaps with method patents insufficiently addressed.

Looking ahead, research on seed exhaustion urgently needs to expand in empirical, detailed, and forward-looking directions. With the rapid development of technologies such as gene editing and synthetic biology, exhaustion dilemmas arising from biological replication may evolve into new forms of legal challenges. At the international level, the key to modernizing China's seed governance and enhancing its influence in global rule-making lies in constructing "soft law" frameworks and bilateral coordination mechanisms to achieve breakthroughs outside rigid multilateral systems. Only through continuous theoretical innovation and institutional experimentation can a future seed industry order be established that simultaneously safeguards innovation vitality and protects food sovereignty.

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