Research Article

The Impact of UPOV 1991 on Plant Variety Protection and Agricultural Innovation: Comparing Case Studies of Singapore and Japan

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Abstract

This article aims to analyze the comparative implementation of UPOV 1991 as a form of international compliance and its impact in Singapore and Japan. The findings of this research reveal that Singapore ratified UPOV 1991 in 2004 and implemented it in the Plant Varieties Protection Act 2004. Meanwhile, Japan ratified UPOV 1991 in 1998 and implemented it in the amendments to the Plant Variety Protection and Seed Act 1978. It provides a 25-year protection guarantee for plant breeders, and the adoption of UPOV 1991 also has various other impacts on Singapore and Japan. Singapore has made notable strides in the agricultural innovation sector and is more actively involved in international cooperation addressing developing effective plant variety protection systems. As for Japan, a more efficient framework for the use of IPR, which increases the competitiveness of domestic agriculture, has been established, and innovation in plant variety testing technology continues to experience advancements that bring numerous benefits to local farmers.

Keywords: Agricultural Innovation; Japan; Plant Variety Protection; Singapore; UPOV 1991

Introduction

Food security is an important issue on the international agenda. New and improved crop varieties are one way to measure adaptability to changing climatic conditions, thus contributing to long-term food security. Biodiversity is essential to food security. Plant variety protection is an intellectual property right (IPR) that aims to provide incentives to invest in the research and development of new and improved plant varieties.

The International Union for the Protection of New Varieties of Plants (UPOV) is an international organization that regulates matters regarding the protection of the intellectual property of new plant varieties. Plant Variety Protection (PVP) is one type of IPR, and other rights such as patents, copyrights, and trademarks. Variety protection regulations are designed specifically for plant varieties and grant exclusive rights to breeders for the propagation of new plant varieties developed by breeders (Dutfield, 2011).

UPOV was first signed in Paris in 1961 and revised in 1972, 1978, and 1991. The UPOV Convention aims to guarantee the rights of breeders, particularly stakeholders in plant breeding, agriculture, and horticulture. The regime is expected to incentivize breeders to develop new plant varieties to promote innovation in agricultural production by ensuring breeders' rights. Under the 1991 Act, the rights include seven actions: production or reproduction, conditioning for propagation purposes, offering for sale, sale or other marketing, exporting, importing, and storage (Medaglia et al., 2019).

The UPOV Convention originated in Europe, and membership expanded to most industrialized countries, with well-developed plant breeding sectors. Then, after the entry into force of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in 1995, UPOV proponents utilized the TRIPS Agreement to expand membership to include countries in the southern region (Sanderson, 2017). Article 27.3(b) of the TRIPS Agreement requires member countries to provide intellectual property protection for plant varieties. TRIPS does not mention the UPOV Convention, allowing for possibilities other than joining UPOV. There are various factors driving countries to become members of UPOV. These include accessing improved seeds and diversifying the seeds available in the country (Dutfield, 2011).

Some countries have acceded to the UPOV due to obligations in free trade agreements. Just as most US free trade agreements require parties to ratify or accede to UPOV 1991, some EU trade agreements with third countries provide access to UPOV 1991, while others require parties to consider complying with UPOV. One such agreement is the Regional Comprehensive Economic Partnership (RCEP), which mandates the ratification of multilateral agreements on IPR for member countries, ensuring that the 15 RCEP countries adhere to the same standards in IPR rules, thereby improving the ease of protection, enforcement, and cross-border cooperation. Thus, RCEP members, such as Singapore and Japan, must approve or ratify international agreements related to intellectual property, including UPOV (Jefferson, 2020).

As a country with an area of 720 square kilometers, Singapore is implementing a 30% agricultural production system to meet its domestic and sustainable nutritional needs by 2030. Despite having only 1% of land for agriculture, the country is maximally managing it for food security and maximizing the capacity of the domestic food agriculture industry. The program led the Singapore Food Agency (SFA) to redevelop the Lim Chu Kang area together with the Agri-Food Innovation Park (AFIP). On the other hand, non-food agricultural goods such as orchids, ornamental plants, aquatic plants, and tissue culture plants have become export commodities and domestic markets. The country is also known as a global exporter of orchids, with 224 species growing naturally in Singapore's forests and nature reserves (NParks Buzz, 2021).

Conversely, Japanese society has started agricultural activities for approximately 2,000 years. Still, geographical conditions, environmental deterioration, and degradation of green natural resources have made agriculture, especially rice, increasingly abandoned (Ito & Hiraizumi, 2008). Most agricultural areas are rural, contributing 1% to the country's GDP. Japan's agrarian areas focus on crop production with intensive farming systems. On the other hand, only about 20% of Japan's agricultural area is suitable for farming (Klein, 2023).

Despite these challenges, the Japanese government is working to create farming practices that are environmentally friendly and integrate with nature. This practice will seek to rejuvenate the agricultural sector in Japan. One example is the Green Corridor Project on the island of Hokkaido, which integrates residents and local organizations and connects fragmented habitats with forests by planting trees and plants in fields, slopes, and wetlands (Nieuwsbericht, 2023).

In addition to those differences, Singapore and Japan are chosen as case studies for two key reasons. Firstly, both possess robust agricultural industries and significant impacts on international trade. While Singapore is a small nation with limited agricultural production, it functions as a vital global trade hub, particularly for the distribution of agricultural goods. In contrast, Japan is one of the world's largest economies and is widely recognized as a major player in the agricultural market. Secondly, the adoption of UPOV 1991 has been instrumental in advancing the legal frameworks and fostering agricultural innovation in both countries. By thoroughly integrating UPOV 1991 into their domestic regulations, Singapore and Japan have emerged as models for other Asian countries seeking to strengthen their plant variety protection laws. The standards established by UPOV 1991, now embedded in Singapore's and Japan's regulations, have catalyzed several beneficial outcomes, such as (a) new plant varieties development, particularly hybrids and genetically modified crops; (b) heightened incentives for further research and collaboration among plant breeders, research institutions, and private companies; (c) improvements in high-tech agricultural practices and agricultural products; and (d) enhanced protection for local agricultural industries.

Given these considerations, it is essential to examine the implications of ratifying UPOV 1991 for Singapore and Japan. This urgency arises not only from the necessity for countries to comply with international treaties, but also from the understanding that such compliance can generate substantial benefits—in this case, adherence to UPOV 1991 is believed to positively influence plant variety protection and promote agricultural innovation. Therefore, this research seeks to address a central question: How has the implementation of UPOV 1991 affected plant variety protection and agricultural innovation in Singapore and Japan?

Literature Review

The topics surrounding countries' compliance with UPOV 1991 and its implications for IP protection in the agricultural sector are important to discuss. However, there is a notable lack of research in this area, particularly related to RCEP member countries. This article aims to fill that gap by examining the implementation of UPOV 1991 as one of the obligations imposed by RCEP, using Singapore and Japan as case studies. Given the limited research available on this topic, the authors will discuss only three pertinent pieces of literature in this section, which focus on IP-related obligations concerning plant materials in various FTAs involving countries in the Asian region.

The first piece of literature to be discussed is a book chapter written by Christoph Antons (2019), Intellectual Property in Plant Material and Free Trade Agreements in Asia. As peasant farming gives way to specialized agriculture, the need for IP law in the agricultural sector becomes increasingly apparent. This, however, is an issue that elicits varying opinions. While high-technology exporting countries endeavor to promote elaborate IP provisions in their trade relations, developing countries tend to be more reluctant to engage in IP-related discussions. This conflicting stance leads to obstacles in ratifying and implementing international agreements regarding IP for plant materials, like UPOV. Nonetheless, Anton observes that despite the contradictory viewpoints, most countries, particularly in Asia, eventually resort to "selective adaptation" by adopting systems akin to UPOV models. Apart from the concern of losing foreign investment from trading partners due to an inadequate protection system, ambition in the biotech and commercial seed industries, and lack of expertise and experience in designing alternative systems, another reason behind the "selective adaptation" phenomenon is the rapid development of FTAs. These FTAs may include provisions that (a) alter Article 27 TRIPS; (b) require ratification or accession to UPOV 1991, or compliance with UPOV standards; (c) require

'endeavor' to make patents available, thereby eliminating the obligation for UPOV membership; (d) accept UPOV 1978 membership while prescribing some standards of UPOV 1991; (e) does not require UPOV membership or standards, but regulate plant variety-related matters in detail; and/or (f) require 'endeavor' to become members of UPOV or comply with UPOV standards. In the context of RCEP, one of the largest FTAs that encompasses multiple Asian nations, it promotes the ratification or accession to UPOV 1991 among its provisions, thereby encouraging its member countries to enhance their IPR on plants and adhere more closely to UPOV standards.

The second piece of literature to be discussed is David J. Jefferson's (2020) article, Compliance with Resistance: How Asia Can Adapt to the UPOV 1991 Model of Plant Breeders' Rights. Since the early 2000s, there has been a growing trend of Asian countries adopting UPOV 1991 despite criticisms that "UPOV essentially promotes a form of neoliberal capitalism that clashes with traditional agricultural practices and local cultures" and "The agricultural models endorsed by UPOV does not align with the non-proprietary and non-commercial practices that are still common in Asia". The significant changes in the legal landscape of IP for plants in Asia can be attributed to two primary factors: hard and soft influences. Hard influences refer to the formal obligations imposed by FTAs that require the ratification and implementation of UPOV 1991-based legislation. Meanwhile, soft influences refer to economic and geopolitical pressures from outside the region (such as technical assistance through workshops and consultations offered by UPOV representatives, projects introducing US-made new commercial crop varieties launched by USDA, and various activities promoting UPOV held by IP Key) and within the region (such as regional organizations and forums advocating for the adoption of harmonized IP for plants and plant breeders' rights— PBR—regulations). As a result, UPOV compliance is becoming increasingly inevitable for many Asian countries. According to Jefferson, it is unfair to expect Asian countries to choose between safeguarding their small farmers through domestic policies or complying with the FTA's-generated obligations to ratify and adopt UPOV standards. Instead, Jeffersons suggests employing a "compliance with resistance" approach. This approach involves (a) making the most of policy space to regulate discretionary exceptions that do not negatively impact non-authorized plant breeders; (b) adjusting regulatory provisions to match local conditions and priorities; and (c) establishing non-proprietary legal frameworks that guarantee diverse types of protection for various plant varieties.

The third piece of literature to be discussed is Understanding the RCEP Intellectual Property Chapter: Benefits for Business, a document published by the Ministry of Trade and Industry of Singapore (2021). While previous works of literature have explored FTAs in general, this literature specifically examines RCEP. Unlike many FTAs that do not place a strong emphasis on IP protection, RCEP dedicates an entire chapter to this subject, highlighting the pressing need for IP protection among countries in the region. A notable illustration of this priority is that in 2019, 75% of global patent filings came from RCEP member countries, with Japan and Singapore ranking second (307,969 filings) and fifth (14,136 filings), respectively. Among the various types of IP, the protection of plant varieties is particularly emphasized in the RCEP IP chapter. RCEP member countries recognize the challenges and costs involved in developing new plant varieties, which require extensive research and experimentation. Consequently, strong IP protection for plant materials is crucial to ensure that these investments yield favorable returns. To address the region's current shortcomings in IP protection for plant material, RCEP mandates that all member countries (a) ratify UPOV 1991, with timelines adapted to their unique contexts; and (b) provide protection through either a sui generis system or an existing patent system. These enhanced protective measures aim to empower plant breeders to develop new varieties that are more productive and easier to grow. Additionally, they seek to boost the competitive edge of the local agricultural industry in the international market.

After a thorough analysis of the three distinct literatures, it can be inferred that the adoption of UPOV 1991 is on the rise, in line with the increasing need for IP protection in the agricultural sector. This trend is propelled by UPOV-related clauses in FTAs, including RCEP, which require that signatory countries ratify, accede to, or comply with UPOV 1991. This may pose new challenges for developing countries that rely heavily on traditional agricultural practices. Conversely, developed countries may reap more significant benefits from these

provisions due to their agrarian sector's greater capacity and different orientations, as well as their ability to utilize policy space and adjust legal frameworks to their domestic conditions and interests. Considering this conclusion, this article will examine the impact of UPOV 1991 implementation on Singapore and Japan's agricultural and IP sectors.

Methods

This article presents descriptive qualitative research aimed at understanding the implementation of UPOV 1991 as a component of RCEP, with Singapore and Japan serving as case studies. It relies on secondary data, including books, journal articles, official documents, and web pages related to the research topic. The data obtained through the literature review will be analyzed using qualitative techniques, encompassing data selection and simplification, data presentation, and conclusion drawing. The analysis will culminate in a descriptive narrative that addresses the central question raised by this article, namely the implications of UPOV 1991's implementation for plant variety protection and agricultural innovation in Singapore and Japan.

This research also utilizing compliance theory, where states reciprocate treaty norms with other parties based on their interests and benefits. The compliance exhibited by states towards international law and treaties is often driven by efficiency, self-interest, and norms (Chayes & Chayes, 1993). Milgram (1963) presented an approach to compliance theory divided into two categories: normative and instrumental. The normative approach suggests that the expectations of others form a moral basis for compliance, in which those who obey the law are seen as consistent with established norms. Law becomes a matter of obligation, where the rule-makers are perceived as capable of regulating the behavior of others—in this context, understood as states. In contrast, the instrumental approach views self-interest as the driving force behind an individual's (or a state's) decisions to act in ways that yield benefits (Purwoko et al., 2022). Thus by respective framework, this article focuses on Singapore and Japan's "rational decision" to join the UPOV regime for their respective advantages. A comparative method will then be used to compare the effectiveness of UPOV implementation in the agricultural sectors of the two countries.

Result and Analysis

The Implementation of UPOV in Singapore and Japan

National Policies Based on UPOV

Singapore became the 55th member country in the ratification of UPOV 1991. The aim of the Singapore government in ratifying UPOV 1991 was to provide space for plant breeders to obtain protection and exclusive rights to proposed plant varieties. This protection prevents other parties from carrying out commercial and non-commercial actions against plant varieties discovered in terms of materials and harvested results. Plant breeders who have obtained licensing rights can request royalties from other parties who will use plant varieties and can mass-produce varieties. This country submitted an instrument of accession for plant protection on 30 June 2004 and took effect on 30 July 2004. The ratification of the plant protection instrument carried out by Singapore was implemented in Law No. 4 of 2004 concerning the protection of plant varieties (UPOV, 2004). This law, also known as the Plant Varieties Protection Act 2004, contains at least 16 chapters that regulate the definition, registration method, and other provisions that must be fulfilled to register and fulfil the qualifications of plant varieties.

This regulation, which has been in effect for ten years, was amended in 2014. This change is intended to expand the list of plants that can be protected. Before the amendments, the Agri-Food and Veterinary

Authority of Singapore (AVA) only had the authority to examine plant varieties. Then, amendments to the Plant Varieties Protection Act in 2014 provided space for the Intellectual Property Office of Singapore (IPOS) to also participate in testing. Examination of new plant varieties proposed by plant breeders. In its duties, IPOS can appoint individuals, groups, or bodies to test and inspect plant varieties proposed by breeders. IPOS carries out this policy to improve the quality of each type of plant variety, and appropriate experts can carry out testing of new plant varieties.

Singapore makes it easy for plant breeders to register claims for new varieties with or without foreign claims. Plant breeders must meet conditions to submit a claim where a plant can be considered a new variety if the elements used and the plant harvest have not been reproduced or have never been bought and sold. Each variety has a different period, such as trees or vines, so they must meet for more than one year in Singapore and more than six months outside Singapore. Meanwhile, other types of plants must fulfill the requirements for more than four years before applying for plant variety protection (Marks & Clerk, 2015). New plant varieties are protected for 25 and 30 years for tree types. Plant breeders will receive an annual bill after the end of the protection period, starting from the end of the first year of protection (Mirandah, 2010).

In contrast to Singapore, Japan, one of the countries with a leading agribusiness industry, ratified UPOV 1978 in 1982 and UPOV 1991 in 1998. Before ratifying UPOV 1987 and UPOV 1991, this country already had a law regarding seeds in 1947. However, this law did not adequately protect PBR. Then, in 1978, Japan passed a law on protecting plant varieties and seedlings, known as the Plant Variety Protection and Seed Act 1978. Compared to the previous law, the Plant Variety Protection and Seed Act 1978 brings more benefits because it also includes rights for plant breeders (Ministry of Agriculture, Forestry and Fisheries of Japan, n.d.).

The ratification of UPOV 1991 in 1998 was contained in amendments to the Plant Variety Protection and Seed Act 1978. This regulation covers several important aspects, including the rights of plant breeders, expansion of the coverage of protected plants to each genus and type, extension of the protection period for plant varieties, expansion of PBR to material harvested by plant varieties, temporary protection program identifier, and introduction to essential derivatives of plant varieties (Ministry of Agriculture, Forestry and Fisheries of Japan, n.d.). Plant breeders' rights regulated in the Plant Variety Protection and Seed Act 1978 amendments make it easy for breeders to register their findings through the Ministry of Agriculture, Forestry, and Fisheries (MAFF). Each plant variety registered by the breeder must contain at least several elements, namely novelty, plant uniqueness, stability, uniformity, and suitability of the denomination of the proposed variety. Plant breeders who pass the test can obtain rights to the proposed plant variety for 25 years and 30 years for tree types (Meno, 2018).

In addition to its compliance with UPOV 1978 and 1991 UPOV, as well as its awareness regarding the fulfilment of PBR, Japan also designed several programs: developing test guidelines for plant varieties; exchanging distinctness, uniformity, and stability (DUS) test data with UPOV member countries; and establishing collaboration with the East Asia Plant Variety Protection (EAPVP) Forum (Meno, 2018). The Japanese government's seriousness in IPR towards protecting plant varieties is reflected in MAFF's 2020 intellectual property strategy. In this strategy, the government seeks to earn income from selling intellectual property on food products worldwide. This strategy aligns with the government's push for every plant breeder to also get their rights by the plant variety protection law (GRAIN, 2020).

The benefits of UPOV ratification will be felt by plant breeders, farmers, and industry. Developing diverse plant varieties gives farmers easy choices for developing new or existing plant varieties. To use seeds or seeds from plant varieties, farmers must pay a certain fee to the plant breeder within a certain period. Under applicable law, farmers can save plant varieties seeds with several exceptions. However, a draft amendment to the PVP law prohibits farmers from saving seeds without permission from the plant breeder. This draft law will make it easier for breeders to sue farmers if they use registered plant varieties without authorization. Those who violate it will receive a maximum prison sentence of 10 years with a fine of 10 million yen for individuals and 300 million yen for businesses (GRAIN, 2020).

Comparison of UPOV Implementation in Singapore and Japan

Adopting the UPOV Convention within the framework of multilateral agreements, including WTO and RCEP, marks a significant step for Singapore and Japan in harmonizing their PVP laws with international standards. Singapore's enactment of the Plant Varieties Protection Act 2004 and Japan's implementation of the amendment to the Plant Variety Protection and Seed Act 1978 reflects their commitment to aligning their legal frameworks with the principles outlined in UPOV 1991 (FAO, 2023a, 2023b). Central to these legal developments are the provisions about PBR, which grant exclusive privileges to breeders in both countries. In Singapore, the Plant Varieties Protection Act 2004 affords breeders protection as outlined in Article 28 Paragraph 1, while Japan's legislation, as articulated in Article 20 Paragraph 1, offers similar rights. These provisions safeguard breeders against unauthorized use, reproduction, and distribution of their protected varieties, ensuring they reap the benefits of their innovation and investment in breeding programs. However, it is essential to note that despite the overarching similarity in granting breeders' rights, nuances exist in the form of exceptions and limitations. Japan, for instance, permits the exploitation of protected varieties for research purposes under Article 21 Paragraph 1, reflecting a balance between incentivizing innovation and facilitating scientific advancement. This provision acknowledges the importance of research in furthering agricultural knowledge and enhancing crop resilience, thus contributing to sustainable farming practices. Moreover, Singapore and Japan employ the DUS criteria concept to determine PVP eligibility. These criteria ensure that protected varieties are distinct from existing ones, display uniform characteristics, and remain stable after repeated propagations. By adhering to DUS standards, both countries uphold the integrity of their plant variety protection systems, fostering confidence among breeders and consumers alike. Furthermore, the duration of protection provided by both Singapore and Japan is consistent with UPOV standards, extending coverage for 25 years. Singapore's Article 24 Paragraph 2 and Japan's Article 19 Paragraph 1 delineate the timeframe within which breeders can assert their rights over their protected varieties. This extended protection period incentivizes long-term investment in breeding programs, encouraging innovation and diversification within the agricultural sector.

Despite these overarching similarities, the implementation of UPOV in Singapore and Japan diverge in certain aspects, reflecting each country's agricultural condition and economic contexts. In this case, Singapore and Japan exhibit notable disparities in their agrarian situations. In Singapore, agriculture plays a minor role in the economy, with manufacturing contributing 20-25% to its annual per capita income. Consequently, Singapore heavily relies on imports to meet its agricultural needs, particularly for fresh fruits, which are scarce domestically (International Trade Administration, 2024). Nonetheless, the country actively promotes the development of plant varieties to enhance food security, investing significantly in agricultural technology and fostering innovation in the farming sector (Kok, 2020). This scenario mirrors Japan's to a large extent, where the nation also relies on imports for certain agricultural products, such as those supplied by the US. However, Japan boasts a more favorable agrarian landscape, with expansive farmland covering 4.3 million hectares as of 2022. This country also supports and encourages the innovation and development of the agriculture sector through investment and technological development in smart agriculture (Jie et al., 2023).

A significant difference lies in the administrative procedures for registering plant varieties. In Singapore, breeders seek protection through the IPOS, whereas in Japan, the process involves submitting applications to the MAFF. This variation in administrative processes highlights the importance of understanding the institutional frameworks that support plant variety protection systems. The selection of administrative authority reflects each country's governance approach, resource allocation strategies, and stakeholder involvement in agricultural policy development. Using existing administrative frameworks, Singapore and Japan aim to simplify the registration process, reduce bureaucratic obstacles, and improve accessibility for breeders seeking protection for their varieties. Another difference can be seen in the application fee for plant variety registration. In Singapore, although registration fees are not explicitly outlined in the law, IPOS has

established a cost of S$1,600 for variety protection (IPOS, n.d.). Conversely, Japan's legislation mandates a registration fee of 14,000 yen increasing to 47,200 yen by 2023 (Branche-Ip, 2023). In this situation, Singapore imposes significantly higher application fees than Japan. This raises concerns about the potential effect of the high registration costs, possibly discouraging people from pursuing plant variety rights (Ministry of Business, Innovation and Employment, 2022). This concern is underscored by data showing that Japan ranked among the five countries with the highest plant variety registrations in 2016, with 977 applicants (WIPO, n.d.).

That said, while Singapore and Japan have embraced the UPOV Convention as part of their commitment to the multilateral agreement, implementing plant variety protection laws reflects nuanced differences tailored to each country's legal, administrative, and economic contexts. By harmonizing international standards with domestic priorities, Singapore and Japan aim to foster innovation, enhance agricultural productivity, and contribute to sustainable development within the region and beyond.

Table 1. Comparison of UPOV Implementation in Singapore and Japan

Aspect	Singapore	Japan
Adoption into domestic regulation	Plant Varieties Protection Act 2004	Plant Variety Protection and Seed Act 1978
Determination of PVP eligibility	DUS standards	DUS standards
Duration of protection	25–30 years	25–30 years
Administrative procedures	Applications are submitted to the IPOS	Applications are submitted to the MAFF
Registration fee	S$1,600 (US$1,217)	¥14,000 (US$97), increased to ¥47,200 (US$327) in 2023

Source: Authors' Analysis

Impact of UPOV Implementation

Impact on Singapore

The implementation of UPOV in Singapore has encouraged innovation in agriculture as it provides a clear legal framework to protect the IPR of plant breeders, enabling breeders to invest time, energy, and resources in developing new crop varieties. However, Singapore is one of the most populous countries in the world, with approximately six million people living in the region. This has led Singapore to sacrifice many things, including food production. In the 1960s, Singapore's agricultural land occupied 14,000 hectares of land, but today no more than 1% of total land is available for agriculture, causing Singapore to import 90% of its food every year (SG101, 2019). Singapore has continuously developed various agricultural technologies, including the vertical farming industry, to overcome this limitation. Vertical farming is a modern method where crops are grown vertically in layers, usually in a multi-story structure.

In recent years, the vertical farming industry in Singapore has grown rapidly as more companies utilize this method to produce crops efficiently and sustainably. Vertical farming is considered one of the solutions to address the challenges of limited land resources and food security, as well as the development of crop varieties in Singapore. To support the development of vertical farming in Singapore, the Urban Agriculture Centre of Innovation (UACOI), supported by Enterprise Singapore, was established to foster research and development of urban agriculture innovation capabilities for small and medium enterprises by October 2022. UACOI focuses its program on three key areas: improving plant health by supporting the development of sustainable plant health products; developing high-yielding crops by identifying and selecting crop varieties

that have desirable traits; and enabling smart agriculture by identifying and supporting the implementation of scalable, affordable automation solutions, and the implementation of cost-effective energy solutions (Republic Polytechnic, n.d.). In addition to UACOI, Singapore has the AFIP in Sungei Kedut, which houses agricultural technology research and development activities and provides indoor plant factories. Singapore's efforts are to ensure food security and spur more excellent economic activity as Singapore positions itself to become a key player in the global agricultural technology industry (SG101, n.d.).

Singapore, which ratified UPOV 1991 in 2004, is known to have been actively involved in developing and applying cutting-edge breeding techniques characterized by continuous efforts to create crops that suit local conditions and global market demands with a focus on achieving food security and environmental responsibility. One of the breeding techniques used by Singapore is Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR), which plays a vital role in the agricultural landscape in Singapore. CRISPR is a technology that can be used to engineer genes. Singapore uses the CRISPR technique to develop crop varieties with improved characteristics, such as higher yields, better nutrition and disease resistance, and adaptability to changing environmental conditions.

Plant breeding with CRISPR techniques drives innovation in agriculture. It is considered promising. It can increase investment and research to address food security issues and the need for better agricultural practices. The main actors involved in breeding genetically modified plants with CRISPR techniques are VWX Plant Sciences, YZ Genetics, and ABC Biotech. These organizations are at the forefront of creating plants with desirable traits. However, there is a challenge to plant breeding with CRISPR techniques, where Cas9 technology that produces genetically modified plants is feared to pose a long-term environmental safety threat. Therefore, balancing innovation in breeding techniques and addressing public concerns requires a comprehensive regulatory framework by the UPOV Convention (6Wresearch, 2023).

The ratification and implementation of UPOV 1991 by plant-breeding countries worldwide, including Singapore, has encouraged international cooperation. UPOV has set global standards for protecting new varieties and plants, creating a common framework for protecting intellectual property rights in new plant varieties and enabling the exchange of knowledge, technology, and practices in plant breeding. Singapore is a member of the EAPVP Forum, which consists of ASEAN and three other countries (China, Japan, and South Korea); it was established in 2007 to exchange ideas and information to develop an effective plant variety protection system consistent with UPOV to contribute to sustainable agriculture and achieve food security (EAVP Forum, n.d.). The organization also allows Singapore to collaborate and build partnerships to conduct joint research in developing new and improved crop varieties.

Finally, the ratification and implementation of UPOV 1991 in Singapore has encouraged plant breeders to develop new plant varieties, including by developing technology or collaborating with other countries that also ratified UPOV 1991.

Impact on Japan

As explained above, UPOV has several advantages for countries that ratify it. One of them is Japan, which has an advanced agricultural sector. With the amendments to the Plant Variety Protection and Seed Act 1978, Japan gained significant advantages in several fields. These include creating, protecting, and applying intellectual property in agriculture, forestry, fisheries, and food industry, which aim to increase Japan's international agricultural competitiveness. As quoted by the National Agriculture and Food Research Organization (NARO), PVP is carried out to develop plant varieties, active utilization, and IPR as the core of disseminating research results for the public interest.

Like the Tsuyahime rice agricultural product from Yamagata prefecture, this product successfully builds a new brand under the PVP system. This is done using a brand strategy of guaranteeing high quality, carried out by

sending seeds and seedlings only to farmers on limited land, skilled farmers with high-standard cultivation methods, and strict delivery standards. The result of the promotion is that the price position is securely the same or better than that of other rice, and then cultivation and distribution volumes increase by around 3 times. The cultivation area was initially only 2,500 ha in 2010, then increased to 8,807 ha in 2016. This shows that PVP can develop local agriculture and increase investment in the domestic and foreign seed industry (Suginaka, 2018). This makes farmers feel more at ease in developing Tsuyahime rice varieties because the market is guaranteed, has been labeled with a good quality trademark, and is trusted by consumers. This is because Tsuyahime rice is cultivated with UPOV protection which allows selected farmers to plant Tsuyahime rice with special cultivation practices that can ensure quality and high value in the hands of consumers. In terms of price, Tsuyahime rice is able to maintain a high market price even though the price of other types has decreased.

Apart from the rice commodity, Japan has also managed to maintain regional excellence in the production of Gentian flower varieties in a relatively short time, seeing that this is a concern because the area was previously only a small plantation in a narrow and steep mountainous region, with an aging agricultural community and high input costs: agricultural facilities and labor. PBR can be produced through the Ashiro Rindo trademark and blending strategy, and several third countries have also given the trademark to Japan. Producers export flowers and produce seeds to producers in other countries. As a result, Gentian Ashiro sends Gentian flowers to the EU and US all year round. It reached 30 billion yen in 1972 and increased to 1 billion yen yearly in 2014 (Meno, 2018). This also provides economic benefits for the Gentian flower-producing city by saving plant varieties through plant protection rights, thus increasing the productivity of local farmers because they have a guaranteed market for Gentian flower commodities. The percentage of protected varieties according to plant type can be classified in several ways. Citing the Export and International Affairs Bureau of the MAFF in the 2021 UPOV seminar, the highest percentage of flowers is 63%; the second tree has a rate of 18%, then followed by vegetables at 6%, plants at 5%, agriculture at 4%, and others at 4% (Miyamoto, 2021).

Some varieties have been successfully developed by farmers outside Japan, such as the Shine Muscat fruit variety, a major Japanese fruit export product. This is because the domestic seed market is large enough to support breeding activities, where Japanese breeders tend not to buy PBR for their varieties outside Japan. As a result, the production and trade of Shine Muscat spread widely in Asia, causing the loss of the Japanese export market and damage to the brand.

Apart from agriculture, ratification of UPOV 1991 for Japan can also provide innovation in testing technology for better plant varieties from other countries, like the DUS test based on the UPOV Convention, which consists of procedures including formality tests, DUS test planning, and denomination tests. Method 1 DUS test includes growing tests carried out by NCSS, especially for ornamental plant and vegetable varieties. Method 2 DUS involves testing using spot inspections carried out by the applicant, who conducts trials on his land as per the instructions of the PVP authority and examiners visiting the field to assess the variety. Method 3 DUS goes through a documentary examination where the applicant only submits a detailed report. The DUS method in Japan receives 1,000 applications every year; this is inseparable from the various developments carried out over 30 years, which can indirectly provide benefits because advances in Japanese plant inspection technology can give a good image for Japan as a country with advanced agricultural technology (Yamaguchi, 2015). Among the plant varieties that have carried out the DUS trial method in Japan, method one can be carried out on ornamental plant varieties, including chrysanthemum, carnation, rose, petunia, calibrachoa, and several food and fruit plants.

In this case, the government, through Atsuhiro Meno–a senior policy advisor from the Intellectual Property Division, Food Industry Affairs Bureau, MAFF–revealed that Japanese plant breeders can directly discuss their agricultural problems (Meno, 2019). UPOV 1991 also changed Japanese variety agricultural regulations by tightening the rules for the entry and exit of several plant varieties, which will be given to plant breeders who want to start their variety business abroad. Breeders also have the right to protect their varieties through

permits protected under the law. UPOV guarantees PBR for 15 years (UPOV, n.d.). In conclusion, UPOV 1991 has significantly impacted Japan's agricultural sector. The positive effects of UPOV for Japan include increasing the income of local farmers due to the increasing quality of farm products that can compete in the global market. It also makes it easier for Japanese farmers to obtain new plant varieties, carry out the latest, sophisticated research, and protect varieties and innovations in agricultural commodities.

Table 2. Impact of UPOV implementation in Singapore and Japan

Impact	Singapore	Japan
Availability of strong legal protection	✓	✓
Improvement in agricultural innovation, partnership, and productivity	✓	✓
Increased international competition	✓	✓

Source: Authors' Analysis

Conclusion

Compared to Japan, Singapore was a bit slower in adopting a plant variety protection policy, as the Plant Varieties Protection Act 2004 only came into effect on July 30, 2004, after Singapore ratified UPOV 1991. On the other hand, Japan already had a similar policy through the Plant Variety Protection and Seed Act 1978, which was later amended in 1998 after Japan ratified UPOV 1991. The policies in both countries cover PBR (with minor differences related to exceptions and limitations), DUS as an eligibility criterion, and the duration of protection. The differences in implementation mainly lie in the administrative procedures and registration fees.

The adoption of UPOV 1991 has had a diverse impact on plant variety protection and agricultural innovation in both Japan and Singapore. UPOV 1991 has resulted in several innovations that have contributed to Singapore's food security. The country has made notable strides in the agricultural sector, particularly in the vertical farming industry, which aims to develop high-yielding crops by selecting crop varieties with desirable traits. Singapore also embraces advanced breeding techniques, including CRISPR, to produce crop varieties with improved characteristics, such as higher yields, better nutritional content, disease resistance, and adaptability to changing environmental conditions. Furthermore, Singapore actively participates in international cooperation, such as the EAPVP Forum. This forum promotes information exchange to develop an effective plant variety protection system following UPOV standards. Singapore's participation in this forum allows it to form partnerships with ASEAN and East Asian countries and collaborate on joint research in developing new and improved crop varieties.

Meanwhile, in Japan, the implementation of UPOV 1991 has resulted in a more efficient framework for using IPR, leading to increased competitiveness of domestic agriculture. The PVP system encourages local farmers to keep cultivating and developing new plant varieties as it provides market guarantees and high-quality trademarks, which can boost consumer confidence. Local farmers no longer need to be afraid to 'experiment' because many 'accidental varieties' have become new products with high economic value. Additionally, UPOV 1991 has spurred innovation in the plant variety testing technology sector, including creating DUS Methods 1–3, which can be applied to a wide range of plants, from ornamental to food crops. These advancements have brought numerous benefits to local farmers, who have seen improved production and product quality and greater ease in obtaining new plant varieties and conducting research.

While Singapore and Japan have undoubtedly reaped benefits from adopting UPOV 1991, it is crucial to acknowledge the potential drawbacks. These include long-term environmental risks stemming from over-reliance on technology to create genetically modified plants, exorbitant seed costs that can prove burdensome for farmers and create inequalities due to disparities in capital, diminished biodiversity in non-legally protected plants, greater reliance on superior seeds produced by multinational corporations, and weakened government sovereignty in regulating domestic agricultural commodities.

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