Plant Intellectual Property: A Comparative Analysis of American, European, and Indian Law with a Focus on Economic Development in the 21st Century

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This paper is about the relationship between the intellectual property ("IP") law of plants, plant innovation, and contemporary economic development. Its thesis is that plant innovation impacts economic development, and that plant IP law can be reformed to drive economic development in ways that are more tailored to 21st century concerns. Specifically, it argues that plant innovation impacts economic development by promoting higher crop yields, mitigation and adaptation to climate change, and improvements in food security. The paper takes a comparative approach to analyze the plant IP regimes of three jurisdictions: The United States ("US"), The European Union ("EU") and India, in order to extract inferences, which inform its recommendations and conclusions. This paper contributes to the literature by offering a novel analysis of these three plant IP regimes within the context of development issues and by offering recommendations for improving Plant IP with respect to these issues.

I. INTRODUCTION

Countries have adopted intellectual property ("IP") regimes that offer protection to plant breeders for the novel varieties they create. A common goal of intellectual property protection in this context is to incentivize the production of additional plant varieties, and ultimately, to incentivize plant innovation. Unlike some areas of intellectual property, however, there is a relatively high degree of variation and controversy surrounding the frameworks adopted from country to country.[1] This makes plant IP ripe for comparative analysis. It also highlights the sensitive, controversial, and important nature of plant IP.

Plant IP is important because incentivizing plant innovation is a means by which economic development can be stimulated.[2] This is possible because plant innovation can bolster crop yields, fight climate change, and promote food security.[3] The world's food supply chains keep civilization from collapsing into an undesirable state of chaos, but these are simultaneously fragile and widely misunderstood. The world's population is largely confined within highly concentrated cities. This creates a separation of most people from food production which leaves them vulnerable to climate change, famine, and their associated economic impacts. Although the world has made substantial progress in plant science and agricultural productivity since the turn of the 20th century, food supply chains remain an Achilles' heel of civilization- one which seriously threatens economic development, especially in developing countries.

For example, hunger remains a critical problem, and a problem that has markedly worsened due to the combined effects of the COVID-19 pandemic as well as the Russia-Ukraine War.[4] Many countries throughout the world suffer

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[1] *See Patent Law Harmonization*, WORLD INTELL. PROP. ORG., https://www.wipo.int/patent-law/en/patent_law_harmonization.htm (last visited Nov. 1st, 2022) (discussing patent law harmonization efforts dating back to the 19th century).

[2] *See infra* Sec. IV.A.1, 2.

[3] *Id.*

[4] *See* FOOD AND AG. ORG. UNITED NAT., THE STATE OF FOOD SECURITY AND NUTRITION IN THE WORLD: REPURPOSING FOOD AND AGRICULTURAL POLICIES TO MAKE HEALTHY DIETS MORE AFFORDABLE xvi, (2022) (hereinafter FAO) (explaining that "the prevalence of undernourishment…jumped from 8.0 in 2019…to around 9.8 percent [in 2021]"); *War in Ukraine Drives Global Food Crisis*, WORLD FOOD

from debilitating levels of food insecurity, and many others lack the agricultural capacity to be self-sufficient, if necessary.[5] This inhibits such countries from achieving robust economic growth and overall societal development.[6] However, plant innovation is a critical component to solving these issues.[7] A contemporary example is seen in the development of golden rice.[8] Another example is biofortified gene edited plant varieties, such as the purple tomato recently approved by the US Department of Agriculture ("USDA").[9] These innovations have the capacity to sharply impact economic development, and insofar as plant IP regimes incentivize such innovations, the regimes should be critically analyzed for reform opportunities.

Plant innovation also has the capacity to promote economic development in a direct sense by improving crop yields, which can help drive local economies and strengthen national economies, especially agrarian ones.[10] American corn production offers an illustrative example. In 1928, prior to the innovations of hybrid and genetically modified varieties, American corn yields averaged 26 bushels per acre.[11] By 2007, average yields had risen to over 149 bushels per acre.[12] Under ideal growing conditions, certain varieties have produced as much as 442 bushels per acre.[13] This has sustained growth in the agricultural sector, which feeds adjacent sectors and the communities which depend on them.[14]

Plant innovation may also drive economic development through aiding the world's effort to mitigate and adapt to climate change.[15] In terms of mitigation, innovative plant varieties can alleviate the necessity for deforestation by

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PROGRAMME (June 24, 2022), https://www.wfp.org/publications/war-ukraine-drives-global-food-crisis-0.

[5] *See Data Visualized Powered by VAM*, WORLD FOOD PROGRAMME, https://dataviz.vam.wfp.org/ (last visited Nov. 1, 2022) (highlighting rates of insufficient food consumption, the database provides the following rates as examples as of October 2022: Afghanistan (89.52%), Somalia (90.79%), Mali (69.5%)); FAO, *supra* note 4, at xvi.

[6] *See infra* Sec.IV.A.6.

[7] *See* FAO, *supra* note 4, at 111 (explaining that biofortification through genetic modification is "among the most cost-effective measures to help prevent micronutrient deficiencies.").

[8] Annika J. Kettenburg et al., *From Disagreements to Dialogue: Unpacking the Golden Rice Debate*, 13 SUSTAINABILITY SCI. 1469, 1469 (2018).

[9] *APHIS Issues First Regulatory Status Review Response: Norfolk Plant Sciences' Purple Tomato*, U.S. DEP'T AG. (Sept. 7th, 2022), https://www.aphis.usda.gov/aphis/newsroom/stakeholder-info/sa_by_date/sa-2022/purple-tomato. The USDA approved Norfolk Plant Sciences' novel tomato variety, which is engineered for its purple appearance and biofortification.

[10] *See infra* Sec. IV.A.2.

[11] MARK D. JANIS et al., INTELLECTUAL PROPERTY LAW OF PLANTS 19 (Janis et al. eds., 1st ed. 2014).

[12] *Id.* at 19. Undoubtedly, plant innovation is not the sole contributing factor in this increase. Innovations in other agricultural technologies such as chemicals, information technology, and soil management also play a role. Parsing the independent impact of each of these innovations is beyond the scope of this paper, however, suffice it to say that plant innovation has made an impact in its own right.

[13] *Id.*

[14] *See* Econ. Rsch. Serv. *infra* note 143.

[15] *See infra*, Sec. IV.A.3.

providing a robust food supply using land that has already been put to agricultural use.[16] Additionally, drought-resistant varieties can reduce the need for irrigation, leaving more freshwater within ecosystems.[17] In terms of adaptation, breeders have already developed plant varieties with an eye towards the impacts that climate change will have on agricultural productivity.[18] Overall, climate change poses significant risks to economic development and societal stability, but plant innovation can help societies navigate these risks.

This article builds upon the existing literature by offering a novel comparative analysis of American, European, and Indian plant intellectual property law, by focusing on the relationship between the three legal systems, plant innovation, and contemporary economic development, and by offering recommendations for plant IP reform. While prior works have examined similarities and differences between approaches to plant IP, they have not taken up a comparative analysis that examines plant IP with an emphasis on development issues and have not offered recommendations for reform in light of all of these issues.[19] This article fills these gaps within the literature.

The thesis of this article has three prongs. First, that a comparative analysis of the three plant IP regimes yields similarities, differences, strengths, and weaknesses between the regimes that are useful for plant IP reform. Second, that there is a critical relationship between plant IP, plant innovation, and economic development. And third, that the recommendations contained herein will cause plant IP to have a bigger impact on economic development by improving incentives for breeders.

The article makes these arguments in four parts. First, in the Background section, it provides the historical and legal context for the three plant IP regimes. Second, in the "Comparative Analysis" section, it establishes similarities, differences, strengths, and weaknesses that exist between and within the three regimes. Specifically, it establishes these within the context of the regimes' legal structure, categories of protection, requirements for protection, and limitations on protection.

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[16] *Id.*

[17] *Id.*

[18] *See* Nicholas G. Karavolias, et al., *Application of Gene Editing for Climate Change in Agriculture*, 5 FRONTIERS SUSTAIN. FOOD SYSTEMS 1, 14 (2021) (explaining that varieties of rice have been successfully gene edited for tolerance to drought, saltwater, northern climates and for enhanced yields).

[19] *See e.g.*, Sergio H. Lence et al., *Intellectual Property in Plant Breeding: Comparing Different Levels and Forms of Protection*, 43 EURO. REV. AG. ECON. 1, 1–29 (2016); Mohan Dewan, *IPR Protection in Agriculture: An Overview*, 16 J. INTELL. PROP. RIGHTS 131, 131–138 (2011); David Jefferson & Meenu Padmanabhan, *Recent Evolutions in Intellectual Property Frameworks for Agricultural Biotechnology: A Worldwide Survey*, 18 ASIAN BIOTECHNOLOGY DEV. REV. 17, 17–37 (2016); Shun-Liang Hsu, *A Comparative Study on Research Exemptions in Plant Breeding Under Intellectual Property Rights Protection*, 6 QUEEN MARY J. INTELL. PROP. 92, 92–110 (2016); Stephen Smith et al., *Elements of Intellectual Property Protection in Plant Breeding and Biotechnology: Interactions and Outcomes*, 56 CROP SCI. 1401, 1401–11 (2016) (leaving the described gaps which this article seeks to fill).

Third, in the Broader Connections and Recommendations section, it establishes a relationship between plant IP, plant innovation, and economic development to justify plant IP reform. It does this by theorizing connections between plant innovation, climate change, crop yields, food security, and economic growth. It then uses the similarities and differences identified within the comparative analysis to offer four recommendations for reforming plant IP to have a greater impact on plant innovation, and ultimately, economic development. The recommendations are that policymakers should: adopt legal structure that incentivizes innovation targeted at addressing development issues; develop limitations on protection that take these issues seriously; give plant breeders more flexibility and choice through categories of protection; and, enhance durations of protection for innovative varieties that impact economic development. Finally, it offers concluding remarks.

II. A BACKGROUND ON PLANT INNOVATION AND THE THREE PLANT IP REGIMES

This section first provides a brief introduction to plant innovation and the seed industry. It then provides an explanation of the plant IP regimes of the United States, the European Union, and India. Although not a comprehensive account of each jurisdiction's law, this section presents a background of the law necessary for understanding the subsequent comparative analysis and the corresponding recommendations for reform. Under US law, there are three forms of intellectual property protection available for newly created plant varieties: plant variety protection ("PVP"), plant patents, and utility patents. Under European Union law, there is one form of intellectual property protection: plant variety rights ("PVR"). Under Indian law, there is also one form of intellectual property protection: plant breeders' rights ("PBR").

A. History of Plant Innovation

Plant innovation is as old as human civilization itself. It is established that human intervention in plant genetics dates back thousands of years.[20] The earliest cultivated plant varieties, such as wheat, rice, barley, and maize, first allowed humans to congregate in concentrated permanent settlements such as cities.[21] This allowed humans to devote additional resources to activities other than sustenance, which put subsequent human innovation into motion.[22]

For most of human history, agriculture was rudimentary and subsistence farming was common across civilizations. Premodern plant breeding largely consisted of passively selecting attractive propagating material for replanting

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[20] HANS STUBBE, HISTORY OF GENETICS: FROM PREHISTORIC TIMES TO THE REDISCOVERY OF MENDEL'S LAWS 5 (T. R. W. Waters trans., 1st ed. 1972). Ancient Assyrian art shows depictions of artificial human fertilization of plant varieties.

[21] PAUL BAIROCH, CITIES AND ECONOMIC DEVELOPMENT 3–4, (UNIV. CHICAGO PRESS 1991).

[22] *See* ARTHUR M. DIAMOND JR., OPENNESS TO CREATIVE DESTRUCTION: SUSTAINING INNOVATIVE DYNAMISM 133–34 (OXFORD UNIV. PRESS 1st ed. 2019) (highlighting the central role of cities in human innovation and providing that "[t]he close agglomeration of cities foster[ed] the creation and spread of ideas. . . .").

rather than actively breeding lines of plants for the expression of particular qualities. [23] There was no specialized knowledge by which individuals could intentionally design new varieties of plants. Different varieties were largely products of environmental factors or genetic mutations. This didn't change until the re-discovery of Gregory Mendel's work at the start of the 20th century.[24] This rediscovery enabled humans to understand the laws of genetics for the first time. Breeders then learned how traits could be inherited by offspring, and how this natural phenomenon could be manipulated. This quickly spawned massive quantities of plant innovation throughout the 20th century, such as the development of hybrid varieties and genetic modification. These innovations and their dissemination came to be characterized as the "Green Revolution."[25] Today, we have arrived at a moment which someday might be characterized as the "Second Green Revolution." Contemporary biotechnological innovations such as CRISPR gene editing could enable plant breeders to unlock genetic expressions that address key issues for economic development, such as climate change and food security.

B. The Modern Seed Industry and Development Impacts

Plant breeding is big business, and the Green Revolution took it from the realm of farmers and nurserymen and turned it into a multibillion-dollar international industry unto itself. This is evidenced by the fact that in 1970, the global seed market was worth a mere one billion U.S. dollars, but by 2010, it had grown to over ten times that amount.[26] Today, the global seed market is worth around $61 billion, and is expected to reach over $100 billion by 2030.[27]

While the market is dominated and saturated by major international corporations in developed countries, such as Pioneer in the US and Bayer in Germany, the market in developing countries still has much room to grow. For example, India has not fully realized agricultural productivity gains which will result from a full adoption of modern plant breeding technologies.[28]

Overall, the impacts of the modern seed industry are immense and far-reaching, with implications for economic development through improvements in

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[23] *See e.g.*, STUBBE, *supra* note 20 (explaining the Ancient Roman concept that "strong seed breeds strong seed").

[24] *Id.*

[25] *See* Norman Borlaug, *Nobel Lecture: The Green Revolution, Peace, and Humanity*, NOBEL PRIZE (Dec. 11, 1970) https://www.nobelprize.org/prizes/peace/1970/borlaug/lecture/#content (associating the phrase "Green Revolution" with the development and dissemination of key modern agricultural technologies, such as hybrid plant varieties).

[26] *The Industry of Plant Breeding*, LAW EXPLORER (Apr. 3, 2016), https://lawexplores.com/the-industry-of-plant-breeding/.

[27] *With 6.5% CAGR, Global Seed Market Size & Share Worth USD 107.8 Billion by 2030: Seed Industry Trends, Demand, Value, Manufacturers, Analysis & Forecast Report by Zion Market Research*, INV. HUB (Jan. 17, 2023, 11:30AM), https://ih.advfn.com/stock-market/stock-news/89996664/with-6-5-cagr-global-seed-market-size-share-wo.

[28] Jogendra Singh et al., *A Review: The Indian Seed Industry, Its Development, Current Status and Future*, 7 INT'L. J. CHEM. STUD. 1571, 1575–1576 (2019).

crop yields, mitigation and adaptation to climate change, and food security.[29] This paper argues that the seed industry could have even greater impacts, however, and that plant IP can be reformed to give it a greater incentive to design innovative varieties that help promote social and economic development, especially with respect to the issues that matter most in our contemporary moment.

C. US Law

1. Plant Patents

Plant patents are issued by the US Patent and Trademark Office ("USPTO"). The Plant Patent Act originally codified the concept of plant patents into existing U.S. utility patent statutes. However, Congress moved these plant patent provisions into their own separate chapter,[30] section 161 of which provides that "Whoever invents or discovers and asexually reproduces any distinct and new variety of plant. . . other than a tuber propagated plant or a plant found in an uncultivated state, may obtain a patent therefor. . ."[31] Section 161 goes on to provide that "[t]he provisions of this title relating to patents for inventions shall apply to patents for plants, except as otherwise provided."[32]

Apparent from the text of the statute are several requirements for patentability. A patentable plant must be invented or discovered and asexually reproduced.[33] Excluded from patentability, however, are tubers[34] and plants found in an uncultivated state.[35] Additionally, the variety must be distinct and new. Distinctness seems largely to be superfluous to the requirement of novelty, as apparently no cases exist where a plant patent application was denied on distinctness grounds under 161.[36] "New" combines with the incorporation clause

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[29] *See infra* sec. IV.A.1, 3, 5.

[30] Townsend Purnell Plant Patent Act, 35 U.S.C. §§ 161–164 (1930).

[31] *Id*. § 161.

[32] *Id*. This is sometimes referred to as the "incorporation clause" because it incorporates the principles of utility patents into plant patents. Litigants have argued that the incorporation clause ropes a smattering of utility patent concepts into plant patent law, with various degrees of success. Much of this is beyond the scope of this paper.

[33] *See* Yoder Bros., Inc. v. California-Florida Plant Corp., 537 F.2d 1347, 1348 (5th Cir. 1976) (explaining that the act of inventing a protectable variety requires identifying new traits and deliberately reproducing them). This three-part standard comes from the principles of utility patent law.

[34] Tubers are defined by the USPTO as plants whose food parts are capable of asexual reproduction. The tuber exclusion is reflective of the socioeconomic situation present at the time the Plant Patent Act was enacted. The US was in the Great Depression during this time and sought to ensure that potato varieties could be utilized in an unrestricted fashion. Rendering tubers patentable would have been problematic as the potato itself is the propagating material used by farmers in producing potatoes. *See* JANIS et al*., supra* note 11, at 192, 193.

[35] Although plants found in a *cultivated* state are patentable. *See e.g.,* Imazio Nursery, Inc. v. Dania Greenhouses, 69 F.3d 1560, 1564 (Fed. Cir. 1995) (explaining the same in dicta).

[36] *See* JANIS et al., *supra* note 11, at 204.

to apply the novelty and loss of right requirements of utility patents to plant patents.[37]

2. Plant Variety Protection

The Plant Variety Protection Act (the "PVP Act") originated as a response to the European development of plant variety rights under the UPOV(the "International Union for the Protection of New Varieties of Plants") framework.[38] The PVP Act was intended to offer protection to sexually reproduced plant varieties and to leave open the possibility of US membership in UPOV. The US became a member in 1981,[39] and therefore the UPOV framework serves as the model for much of the US's plant variety protection scheme.

The Plant Variety Protection Act established the concept of plant variety protection rights.[40] Applications for Protection are made to the US Department of Agriculture's Plant Variety Protection Office (PVPO). The PVPO issues "plant variety protection certificates" that offer protection for up to twenty years, or twenty-five years in the case of vines and trees.[41]

Furthermore, it provides that protectable varieties must be new, distinct, uniform, and stable.[42] The burden of showing these criteria are on the applicant, and the Office relies on representations made in applications to evaluate the criteria.[43] New means that "on the date of filing. . . propagating or harvested material. . . has not been sold or otherwise disposed of. . . by or with consent of the breeder. . . for purposes of exploitation of the variety."[44] Distinct means that "the variety is clearly distinguishable from any other variety the existence of which is publicly known or a matter of common knowledge at the time of the

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[37] *Id.* at 205.

[38] *See id.* at 89–90 (explaining that, because American policymaking opinion on plant breeders' rights was sharply divided, and because of lobbying from the seed industry (largely producers of *sexually* reproduced plant varieties), Congress decided to design a form of protection separate from but similar to the European style, to exist independently of the existing plant patent framework and to apply to sexually reproduced varieties).

[39] UPOV, *Members of the International Union for the Protection of New Varieties of Plants*, (last visited Nov. 1, 2022), https://www.upov.int/edocs/pubdocs/en/upov_pub_423.pdf.

[40] Plant Variety Protection Act, 7 U.S.C. § 2402(a)(1) (2018) [hereinafter PVP Act] ("the breeder of any sexually reproduced, tuber propagated, or asexually reproduced plant variety (other than fungi or bacteria) who has so reproduced the variety, or the successor in interest of the breeder, shall be entitled to plant variety protection").

[41] The logic of this is that vines and trees take longer to bear fruit, so this should be accounted for in the duration of protection, as breeders or their licensees will need a longer amount of time to recoup investments through sales of the new variety.

[42] PVP Act, *supra* note 39.

[43] JANIS et al., *supra* note 11, at 98.

[44] *Id.;* PVP Act, *supra* note 39. To bar protection, this conduct must have occurred more than one year prior to filing, if such conduct occurred within the US, or if such conduct occurred outside the US, four years or six years for trees and vines.

filing of the application."[45] Uniform is defined "in the sense that any variations are describable, predictable, and commercially acceptable."[46] Stability means "that the variety, when reproduced, will remain unchanged with regard to the essential and distinctive characteristics of the variety. . . ."[47]

3. Utility Patents

Plant breeders became dissatisfied with the strength and availability of their protection under the Plant Patent Act and Plant Variety Protection Act and sought to establish utility patent protection as well. The concept of utility patent protection for plant varieties gained traction within the USPTO following the Supreme Court's 1980 decision in *Diamond v. Chakrabarty*, which held that living organisms (specifically, bacteria) were protectable under the utility patent statute.[48] Under *Diamond*, the Patent Office began issuing utility patents for plants.[49] This practice went unchallenged for many years, due to the lack of litigants which had an incentive to challenge its legality.[50] However, in 2001, a sufficiently disinterested litigant finally emerged. In *JEM Ag v. Pioneer Hi-Bred*, a seed company (Pioneer) accused a seed dealer (JEM) of infringing its utility patents for corn varieties. JEM argued that the patent was invalid because plant varieties are not patentable under the utility patent statute.[51] The Supreme Court ultimately held that the patent was valid, and that the utility patent statute contemplates protection for plant varieties.[52]

Therefore, the statutory contours of the utility patent framework apply in full to plants. A full outline of this framework and the relevant case law is beyond the scope of this paper; however, utility patent principles are similar to and different from other forms of plant IP protection. This paper will incorporate these principles into its analysis in the sections below. In summary, however, issuance of a utility patent requires an applicant to show that their invention is useful, novel, and non-obvious.[53] Utility patents are valid for twenty years from

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[45] *Id.* § 2402(a)(2) (noting the PVP Act further provides that distinctness criteria "may be based on. . . morphological, physiological, or other characteristics"); 7 U.S.C. § 2401(b)(5) (2018) (noting the distinctness inquiry is therefore particular to the species in question). UPOV publishes guidelines for hundreds of species.

[46] *Id.* § 2402(a)(3). Conceptually, this is identical to uniformity under EU and Indian law.

[47] *Id.* § 2402(a)(4) (noting that practically speaking, stability is presumed to be sufficient where there is a showing of uniformity); *See* JANIS et al., *supra* note 11, at 98 (explaining the same).

[48] Diamond v. Chakrabarty, 100 S. Ct. 2204, 2205 (1980).

[49] *See Ex Parte Hibbard*, 227 U.S.P.Q. 442 (P.O. Bs. Of Pat. App. and Inter'f. 1985) (holding that plants were patentable under the utility patent statute).

[50] Potential litigants in plant utility patent cases were generally plant breeders such as seed manufacturers, who themselves had an interest of their own utility patents. No such litigant would rationally question the validity of all plant utility patents.

[51] *J.E.M. Ag Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc.,* 122 S. Ct. 593, 595 (2001).

[52] *Id.*

[53] 35 U.S.C §§ 101–103 (2012).

the date of filing. Acts of infringement are defined to include an array of conduct such as selling and importing.[54]

D. EU Law

The EU itself, as an intergovernmental organization of its member states, became a UPOV member after the 1991 Convention.[55] The European Commission thereafter adopted Council Regulation No. 2100/94 (the "Basic Regulation"), to bring Community law into compliance with the Convention and to provide the framework for EU Plant variety rights ("PVR"), the sole form of plant IP under what is now called European Union law. The European framework on PVR is unique from its other forms of intellectual property protection because it is the only field of intellectual property where there is no formal EU-wide legislation that regulates harmonization of the member states' laws to a common standard.[56]

The EU Plant variety rights system is independent and autonomous of member state systems' laws on plant IP. It "neither substitutes nor harmonizes" but acts as an "alternative" to national systems.[57] Under EU law, a plant breeder may obtain either national-level or EU-level protection for their varieties, but protection cannot be simultaneous under both. The effect of this is that a breeder may obtain national and EU-level recognition of a PVR, but the national-level protection lies dormant, unless and until the EU-level recognition is no longer active.[58]

The EU system is headed by the Community Plant Variety Office (PVO). The PVO has delegated application examination responsibilities to national-level institutions, some of which predated the EU and were governed solely under UPOV.[59] Despite the nationally administrated nature of the system, national-level examination offices operate identically in terms of examination procedure and scope of protection. As a general matter, rules governing substance and procedure of plant variety rights per se are determined by the Basic Regulation and associated implementing regulations, although application of member state laws does occur in considering rules particular to issues of infringement, calculating damages, and court procedure.[60] The purpose of mentioning this is simply to establish that an analysis of EU law on the issue of plant IP will be largely, but not entirely, applicable to each EU member state.

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[54] 35 U.S.C § 271 (2010).

[55] UPOV, *supra* note 39.

[56] GERT WURTENBURGER ET AL., EUROPEAN UNION PLANT VARIETY PROTECTION 4, (OXFORD UNIV. P. 2021).

[57] *Id.* at 4.

[58] *Id.* at 6.

[59] *Id.* at 6.

[60] *Id.* at 5.

In order to be protectable, a plant variety must be novel, distinct, uniform, stable, and properly denominated.[61] Distinctness, uniformity, and stability are technical requirements subject to specific regulations of the PVO, which is responsible for conducting "DUS testing" on plant varieties for which protection is sought.[62] The Basic Regulation defines novelty,[63] distinctness,[64] uniformity,[65] and stability[66] in general accordance with international principles, although there are deviations.[67] It also lays down rules related to the formal legal names of varieties, which is referred to as a denomination.[68]

EU plant variety rights last for a term of twenty-five years, or thirty years in the case of vines, trees, and certain other varieties.[69] Only the holder of a plant variety right may authorize the production, conditioning for propagation, sale, marketing, importing, exporting, and accumulation for the aforementioned conduct of the holder's plant variety.[70] The scope of this right extends to propagating material, harvested material, and potentially to products derived

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[61] WURTENBURGER, *supra* note 56, at 35.

[62] *Id.* at 36, 77–78.

[63] *See* Council Regulation (EC) No. 2100/94 on Community Plant Variety Rights, 1994 O.J. (L 227) 5–7 (hereinafter "Basic Regulation") (providing that "[a] variety shall be deemed to be new if, at the date of application. . . variety constituents or harvested material. . . have not been sold or otherwise disposed of to others, by or with the consent of the breeder. . . for purposes of exploitation. . . .") (noting this requirement applies for conduct occurring more than one year prior to application, for conduct within the EU, and for four (all plants) or six years (trees/vines) for conduct outside the EU).

[64] *See id.* art. 7(1) (providing that "[a] variety shall be deemed to be distinct if it is clearly distinguishable by reference to the expression of the characteristics that results from. . . any other variety whose existence is a matter of common knowledge on the date of application. . . .") (noting that conceptually, distinguishability is a species-specific and highly technical inquiry made possible through extensive EU guidelines based on UPOV); WURTENBERGER, *supra* note 56, at 38 (noting that common knowledge can be attributed to a variety which has been protected, registered, or even sold or distributed, prior to registration with the PVO).

[65] *See* Basic Regulation, *supra* note 63, art. 8 (providing that "[a] variety shall be deemed to be uniform if, subject to the variation that may be expected. . . it is sufficiently uniform in the expression of those characteristics which are included in the examination for distinctness. . . .") This merely involves testing the variety to ensure that it does not produce more "off types" or a greater than standard deviation of variation from proper reference varieties; WURTENBERGER, *supra* note 56, at 45.

[66] *See* Basic Regulation, *supra* note 62, art. 9 (providing that "[a] variety shall be deemed to be uniform if, subject to the variation that may be expected from the particular features of its propagation, it is sufficiently uniform in the expression of those characteristics which are included in the examination for distinctness.") This requirement is designed to guarantee that varieties do not change or mutate to become unrecognizable across multiple generations. In practice, it is tied to uniformity, but protection may be rescinded if a variety commercially proves to be unstable; WURTENBERGER, *supra* note 56, at 48–49.

[67] WURTENBERGER, *supra* note 56, at 39–48.

[68] *See* Basic Regulation, *supra* note 63, art. 50(3), 63(1), 63(2–4) (providing that applications contain a denomination that is suitable) (noting suitable denominations have not already been claimed in a Member State, UPOV state or other states as the EU regulations provide, are not likely to be confused with other).

[69] WURTENBERGER, *supra* note 56, at 185.

[70] Basic Regulation, *supra* note 63, art. 13(2)(a–f).

from harvested material.[71] It also extends to essentially derived varieties[72] and to the denomination of the plant variety itself.[73]

There are several limitations on the scope of PVR's. These are the farmers' privilege,[74] "acts done privately and for non-commercial purposes,"[75] "acts done for experimental purposes,"[76] "acts done for breeding, or discovering other varieties,"[77] "compulsory exploitation rights,"[78] and the concept of exhaustion.[79]

E. Indian Law

India enacted its plant IP laws most recently out of the three jurisdictions. Traditionally, Indian law offered no protection for plant varieties, viewing them as belonging to the "common heritage of mankind."[80] The Protection of Plant Variety and Farmers' Rights Act of 2001 (the "PPVFR Act") changed this by formally recognizing plant IP under Indian law, and by providing for rules and administrative mechanisms to govern the same. The PPVFR Act was motivated by the desire to bring Indian law into compliance with TRIPS,[81] but this was not without controversy. The controversiality of the Act necessitated additional considerations, specifically, to accommodate "the interests of farmers", which resulted in a framework that "treat[s] the farmers on par with breeders and researchers in plant varietal development."[82]

The PPVFR Act provides that inventors of plant varieties may apply and receive legal protection for those varieties. This protection is referred to as "plant breeders' rights" ("PBR's"), and such rights are regulated and granted by the Protection of Plant Varieties and Farmers' Rights Authority (the "Authority").[83] Plant breeders' rights offer a period of protection of fifteen years from the date a

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[71] WURTENBERGER, *supra* note 56, at 138–141.

[72] *Id.* Put simply, an essentially derived variety is a variety that is created by using another variety as an input.

[73] *Id.*

[74] *See* Basic Regulation, *supra* note 63, art. 14(1–3) (providing that "farmers are authorized to use for propagating purposes in the field, on their own holding the product of the harvest which they have obtained by planting, on their own holding, propagating material of a variety other than a hybrid or synthetic variety, which is covered by a Community plant variety right.") (noting this privilege only applies to an express list of twenty-two species) noting that farmers not considered "small farmers" are required to pay "equitable remuneration" to the rights holder).

[75] Basic Regulation, *supra* note 62, art. 15(a).

[76] *Id*. art. 15(b).

[77] *Id.* art. 15(c).

[78] *Id.* art. 29.

[79] *Id.* art. 16.

[80] R.R. HANCHINAL & RAJ GANESH, PROTECTION OF PLANT VARIETIES & FARMERS' RIGHTS: LAW, PRACTICE & PROCEDURE, 13 (E.L. House 2018).

[81] Dewan, *supra* note 19, at 135.

[82] HANCHINAL & GANESH, *supra* note 80, at 13.

[83] The Protection of Plant Varieties and Farmers' Rights Act, 2001, §3(1) (India) [hereinafter PPVFR Act].

breeder is granted a certificate of registration, or eighteen years in the case of trees and vines.[84]

A strikingly unique aspect of Indian plant variety law is that it considers "extant varieties" and "farmers' varieties" to be distinct categories of plant varieties which are protectable.[85] Extant varieties are varieties which existed prior to the passage of the PPVFR Act that were essentially common knowledge.[86] Farmers' varieties are varieties that have been traditionally developed and cultivated within localized communities of farmers.

Additionally, essentially derived varieties are considered protectable, and are treated as a subset of either a new or extant varieties.[87] The PPVFR Act defines essentially derived varieties in an identical manner to UPOV.[88] The Authority's regulations provide that essentially derived varieties must meet the same requirements for protection as new or extant varieties but are subject to less rigorous testing.[89] A variety essentially derived from a famers' variety is not protectable "without the consent of farmers or group of farmers who have made contribution[s] in the preservation or development of such variety."[90]

The Act provides a breeder with the right to produce, sell, market distribute, import, and export the variety to the exclusion of all others who undertake these acts, besides of course, those who fall within exceptions to the scope of PBR's.[91] The PPVFR Act imposes an important limitation on the scope of a plant breeders' right, through the concept of "farmers' rights". Specifically, the Act provides that "[Farmers] shall. . . be entitled to save, use, sow, resow, exchange, share or sell his farm produce including seed of a variety protected under this Act. . . [in an unbranded manner]."[92] This means that a plant breeder does not have a cause of action for infringement against a farmer who duplicates a protected variety and sells it for profit, so long as the farmer does not also infringe upon the registered name of the variety.

The Act provides that for a variety to be protectable, it must be new, distinct, uniform, and stable.[93] Novelty depends on the extent to which a variety has been commercialized and exploited.[94] Varieties that have not been commercialized or

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[84] HANCHINAL & GANESH, *supra* note 80, at 13.

[85] PPVFR Act, *supra* note 83, §2(j).

[86] HANCHINAL & GANESH, *supra* note 80, at 89.

[87] *Id.* This means that the duration and scope of protection for essentially derived varieties is identical to new or extant varieties.

[88] *Id.* at 86.

[89] *Id.* at 89.

[90] *Id.* at 90.

[91] Dewan, *supra* note 19, at 136.

[92] PPVFR Act, *supra* note 83, § 39(1)(iv).

[93] *Id.* §15(1).

[94] HANCHINAL & GANESH, *supra* note 79, at 63.

exploited for longer than one year upon the date of filing for protection are considered novel.[95]

Distinctness requires that a plant variety differs in at least one of its "essential characteristic[s] from any other variety whose existence is a matter of common knowledge in any country at the time of filing. . . ."[96] Essential characteristics are determined on a species-by-species basis by the Authority,[97] and are defined as "traits. . . which are determined by the expression of one or more genes. . . that contribute to the principal features, performance or value of the plant variety."[98]

Uniformity and stability are related but independent concepts. Uniformity is essentially defined to mean that a variety produces no more than a specified degree of "variation" in its "essential characteristics."[99] In other words, if a plant variety produces too many unique specimens within a given sampling of its seed, then it is not sufficiently uniform. The standards for permissible amounts of so-called "off types" are determined by the Authority, and significantly, the threshold number of permissible "off-types" for farmers' varieties may be double that of new varieties.[100] A plant variety is stable "if its essential characteristics remain unchanged after repeated propagation."[101] In other words, a variety is not stable if its essential characteristics change to an unacceptable extent across multiple generations of propagation.

III. A COMPARATIVE ANALYSIS OF THE THREE PLANT IP REGIMES

This section will analyze the similarities and differences between the three legal regimes. It will also analyze their various strengths and weaknesses. This portion of the paper provides the core of the comparative analysis, upon which its recommendations rest. Specifically, using the similarities, differences, strengths, and weaknesses identified here, the paper will then put forth recommendations for reform while justifying the importance of such reforms by theorizing broader connections between plant innovation, plant IP, economic development, and related issues.

Overall, it establishes that the regimes differ in terms of legal structure, requirements for protection, duration of protection, scope of protection, and limitations on protection. This section also establishes that the three regimes share many similarities, worth briefly discussing here. All three regimes share a strong influence from UPOV. The American concept of PVP, the European concept of PVR, and the Indian concept of PBR, all share the requirements of

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[95] *Id.* at 63, 67. Importantly, varieties that have been commercialized or exploited exclusively outside of India are subject to an alternative time limit of "six years for trees and vines" and "four years in any other case."

[96] PPVFR Act, *supra* note 82, § 15(3)(b).

[97] HANCHINAL & GANESH, *supra* note 79, at 63.

[98] PPVFR Act, *supra* note 82, § 2(h).

[99] *Id.* § 15(3)(c).

[100] HANCHINAL & GANESH, *supra* note 80, at 44.

[101] PPVFR Act, *supra* note 82, § 15(d).

distinctness, uniformity, and stability, and all three define these concepts in largely equivalent terms. Additionally, all three systems contain the UPOV concept of a non-patentlike form of protection.

A. Similarities, Differences, Strengths, and Weaknesses

1. Legal Structure

This paper refers to the institutional design of the of the regimes and the procedure they impose upon applicants as "legal structure." It examines two aspects of legal structure with respect to the regimes, particularly, application fees and testing burden. These aspects of legal structure impact a regime's accessibility.

The general logic of offering protection for plant varieties, under any legal regime, is to promote the development of new varieties, which may produce benefits for society. The history of plant breeding shows that large commercial enterprises and small-time botanists are each capable of making valuable contributions in this regard. A system should be accessible to all breeders, large and small. There are many individual gardeners, amateur botanists, students, and farmers who are capable of producing new plant varieties.[102] Very few of them have a reasonable chance at accessing protection for their creations, due to their lack of financial resources and technical knowledge. Therefore, accessibility is a strength to plant IP systems because it incentivizes large enterprises and individuals alike to produce innovative varieties.

Relatively higher accessibility barriers likely exist under the American system's framework, whereas the European system is relatively more accessible, and the Indian regime is the most accessible. Illustrations of this are seen in aspects of application procedure, particularly, in fees and testing burdens.

a. Fees

Under any regime, obtaining protection for plant varieties requires paying fees to the government institution issuing the protection. Table 1[103] is composed of the fees applicants face to obtain various categories of protection. Some comparisons are immediately apparent. First, fees under the Indian system are materially lower than the other two systems. Second, while the fees for American plant variety protection are relatively equivalent to fees for EU plant variety rights, fees for American utility patents and especially plant patents are

[102] *Our Mission*, SEED SAVERS EXCHANGE, https://www.seedsavers.org/mission (last visited Nov. 4, 2022) (providing an example of an independent group promoting new plant varieties); *See, e.g., Tall Corn,* IOWA STATE FAIR, (Aug. 11, 2023), https://www.iowastatefair.org/participate/competition/results/tall-corn (recognizing participants who grew the tallest corn specimens and an event where participants compete to develop superior botanical specimens).

[103] *Trusted Global Currency Converter & Money Transfers*, XE, www.xe.com (last visited Oct. 14, 2022) (noting that currencies are reflected in USD in the chart, at the prevailing exchange rate as of October 14, 2022. This is done for ease of comparison). See footnotes for national currency equivalents. The analysis excludes other fees which are in most cases incidental to certain actions taken with respect to an already-issued patent, such as obtaining certified copies or making amendments.

materially lower than for EU plant variety rights. Third, American examination fees are much lower than under any other system. Fourth, the Indian system is unique because it charges a maintenance fee based on sales and royalties obtained from the protected variety in the preceding calendar year. Fifth, whereas the US and India adjust fees based on the nature of the applicant, Europe does not do this.

Overall, based on these differences in fee structure, it seems that the American and Indian systems are relatively stronger in terms of their accessibility to smaller or amateur breeders, based on the fact that they account for the nature of the applicant in determining fees. The Indian system is potentially problematic though, in that some fees are based on the income the breeder receives from the protected variety, because this is quite literally punishing breeders for producing varieties of value. Additionally, one must account for the fact that, under the American system, a breeder is more likely to require the assistance of counsel in proving compliance with requisite variety qualities.[104] Although smaller breeders can always engage in self-help in navigating the application process, the fact that the American and Indian systems impose less of a fee burden on applicants will materially reduce burdens for obtaining protection in some cases.

Table 1

Category of Protection	Filing Fee	Maintenance Fee (Annual)	Examination Fee	Other
US Utility Patent	$555 – $2,220[105]	Depends on duration,[106] roughly $197 – $791[107]	$200 – 800	

[104] This is because only the American system places the testing burden on applicants. *See infra*, Sec. III.A.1.b; Benjamin Hanrahan, *How Much Does it Cost to Obtain a Patent?,* GERBEN IP, https://www.gerbenlaw.com/blog/how-much-does-it-cost-to-obtain-a-patent/ (last visited Nov. 25, 2022) (providing that a plant patent application can cost up to $8,000 including attorney's fees).

[105] *USPTO Fee Schedule*, US PATENT AND TRADEMARK OFFICE, (July 1st, 2024) https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule (hereinafter, "USPTO"). This is comprised of filing, search, and issue fees which range based on applicant. Additionally, this does not include fees for application size, which range from $105 to $420.

[106] *Id.* Maintenance fees are due at 3.5, 7.5, and 11.5 years, range based on applicant. At 3.5 years, ranges from $500 to $2,000. At 7.5 years, ranges from $940 to $3,760. At 11.5 years, ranges from $1,925 to $7,700.

[107] *Id.* Assuming that a patent is maintained for its entire duration but takes three years to issue, total maintenance fees would range from $3,365 to $13,460, and assuming that these costs are amortized over the 17 years of the patent's formally effective life.

US Plant Patent	$375 – >$1,500[108]	$0[109]	$165 – $660	
US Plant Variety Protection	N/A	N/A	N/A	One lump sum fee of $5,150[110]
EU Plant Variety Rights	$438 – $779[111]	$321	$1,850 – $3,798[112]	
India Plant Breeders' Rights	$0 – $607[113]	$0.12 – >$24[114]	$121 – $607[115]	

b. Testing Burden

Another key difference between the regimes is seen in where they place the testing burden. While the structure of the EU and Indian systems places the burden on government institutions, the American system places this burden on applicants.[116] Proving the requirements for protection likely requires the involvement of consultants and lawyers, which costs more than the state would have to pay an examiner for the same work.[117] This raises questions about whether, from a cost-benefit standpoint, the American privatization of the testing function is worth it to society. It is unclear whether the American system's privatization of the testing burden is more efficient in terms of the lower overall cost of issuing and obtaining protection. The above discussion on fees shows that, at least, the American system does reflect this privatization in

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[108] USPTO, *supra* note 105. This is comprised of filing, search, and issue fees which range based on applicant, the filing fees range from $55 for micro entities, $110 for small entities, and $220 for all other applicants. Additionally, this does not include fees for application size, which range from $105–$420 based on applicant.

[109] *See* 35 U.S.C. § 41(b). No maintenance fees are required for plant patents.

[110] *PVPO Services and Fees*, US DEPT. AG., https://www.ams.usda.gov/services/plant-variety-protection/pvpo-services-and-fees (last visited Nov. 4, 2022).

[111] *Fees and Payments*, COMMUNITY PLANT VARIETY OFFICE, https://cpvo.europa.eu/en/applications-and-examinations/fees-and-payments (last visited Nov. 4, 2022). Ranges from EU450–800. Depends on whether application is paper or electronic.

[112] *Id*. Ranges from EU1900–3900, depending on species.

[113] *Fees Details*, MINISTRY AG. AND FARMERS WELFARE (Jan. 31, 2022), https://plantauthority.gov.in/fees-details (hereinafter, "PPVFRA") Ranges from RU0-–50,000. Farmers varieties have no application fee, and essentially derived, extant, and new varieties range from RU7,000 for individual registrations, RU10,000 for educational, and RU50,000 for commercial.

[114] *Id*. Ranges from RU10.00–2,000. Farmers' varieties have an annual fee of 10 rupees. Other varieties are RU2,000 plus 0.1 percent of prior year's sales and 1 percent of prior year's royalties received for most extant varieties or .2% of sales and .5 percent of royalties received for new varieties.

[115] *Id.* Ranges from RU10,000–50,000, depending on species.

[116] The same is true for American utility patents, but with different criteria, as previously explained.

[117] Hanrahan, *supra* note 104.

its lower examination fees. What is not clear is whether this lower cost to applicants is worth it due to the increased cost of proving compliance, or whether the Indian/European approach is ultimately more accessible due to the state absorption of testing burden.

One aspect of testing burden ties directly into the time it takes to obtain protection, or the time burden of navigating a given regime to obtain protection. The European and Indian systems, by imposing testing burdens on the government, require some applicants to wait around while the government tests their variety for qualities that the applicants themselves have already tested for. Most applicants likely breed their varieties deliberately and with the intent of obtaining protection, so most are likely breeding in contemplation of distinctness, uniformity, and stability, and likely could produce evidence of this. The American system allows applicants to obtain official protection faster by examining the quality of the evidence that the applicants have produced as a matter of course in their work. The European and Indian systems pay examiners to generate this evidence, which is likely duplicative and therefore inefficient. This can be a material benefit to applicants who may be waiting for official protection before launching beneficial varieties into the market.[118] Therefore, it may be that the American system is more efficient in getting applicants through the process than the European and Indian systems. This can also benefit third parties, like consumers, who may be able to access beneficial varieties sooner.

2. Categories and Requirements of Protection

This section analyzes the categories of protection offered by each regime, and the essential legal requirements that a plant variety must satisfy to qualify for protection therein. The three regimes offer five different categories of protection for plant varieties. The US regime offers plant variety protection, plant patents, and utility patents, the EU offers plant variety rights, and India offers plant breeders' rights. First, it compares patents (utility patent and plant patents) to "plant rights" (PVP, PVR, and PBR). Then it compares the three forms of plant rights.

a. Patents vs. Plant Rights

A key similarity between plant patents and plant rights is that both can provide a breeder with exclusive commercial monopoly rights over the creation of a plant variety for a limited amount of time. A key difference is that the requirements for protection under a plant right are relatively less onerous and more simple to adjudicate, yet the protection granted is less extensive because they are subject to exceptions such as the breeder's exception.

An illustration of this is seen in the American system. American plant patent requirements focus on novelty and incorporated utility patent concepts while functionally blending distinctness with novelty. Meanwhile, the European and Indian regimes focus on distinctness alone, without regard to utility patent

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[118] Consider the case of trees, which take a very long time to grow. An applicant may have to wait years for the government to independently verify the qualities of their variety.

concepts of novelty per se.[119] At a high level, distinctness focuses on whether there is a difference between existing varieties and the variety for which protection is sought. Novelty, on the other hand, means more than distinctness. For example, via the Plant Patent Act's incorporation clause, the American system subjects breeders to novelty requirements regarding public use and prior art under 35 USC 102.[120] Naturally, these differences also exist between utility patent protection and plant rights protection. The key idea is that patent like categories of protection under the American system are more difficult to obtain and more burdensome to litigate.

Despite this difficulty, the American regime offers breeders forms of patentlike protection, whereas India and the European Union primarily offer only plant rights. The consequence of this is that American breeders have access to relatively stronger protections that are necessarily more difficult to adjudicate whereas European and Indian breeders have access to relatively weaker protections that are less administratively burdensome. These themes are apparent throughout this paper. However, a unique quality of the American regime is that it also offers breeders a form of non-patent like protection, giving some breeders flexibility and choice in how they pursue protection. This flexibility and choice are valuable to breeders, and reflects a relative strength of the American approach, as breeders have the ability to incorporate qualities of their innovations into the decision on pursuing protection.

b. American PVP vs. European PVR vs. Indian PBR

The three regimes are somewhat functionally equivalent with respect to American plant variety protection, European plant variety rights, and Indian plant breeders' rights, at least in terms of their requirements for protection. Each system is based off of the UPOV concepts of distinctness, uniformity, and stability, as explained above. However, the systems differ in that the American regime only extends plant variety protection to sexually reproduced varieties, whereas the other systems do not make this distinction.[121]

Therefore, the American system is fundamentally different from the other two regimes in that through its categories and requirements for protection, it tends to push more breeders towards patent like forms of protection, whereas the European and Indian systems establish categories and requirements for protection which accommodate more varieties through breeders' rights. The American regime is strong in that it offers some breeders flexibility and choice among patent-like or rights-like forms of protection which allows breeders to make more strategic commercial decisions regarding protection. However, the

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[119] *See* JANIS et al., *supra* note 11, at 202–03 (explaining that "[i]n contrast to the law of plant breeders' rights, in which the distinctness criterion is a central prerequisite for protectability, the distinctness requirement [of section 161 of the Plant Patent Act] has remained relatively unexplored. . . .The legislative history of the plant patent provisions suggests that the distinctness requirement functions like a novelty requirement. . . .That is not the case in UPOV-based plant variety protection schemes, where novelty plays a much more circumscribed role and distinctness is a critical element of patentability.").

[120] *Id.* at 205–11.

[121] *See* JANIS et al., *supra* note 11, at 89–90.

European and Indian systems are strong in that they offer a less onerous process by which breeders can obtain and enforce protection for their varieties.

Additionally, the Indian system is particularly different in the categories of varieties that it recognizes as protectable. Unlike European and American law, Indian law extends protection to extant varieties and farmers varieties, and also recognizes essentially derived varieties as a protectable form of variety, subject to the consent of the original breeder. As explained above, the requirements for protection that apply to these categories of varieties are less rigorous than those which apply to other new varieties. The Indian system is particularly stronger in accessibility than the American and European systems. One reason for this is the Indian concept of the "farmer's variety." As previously explained, farmer's varieties are held to less stringent standards than other varieties. Additionally, farmers are subject to a reduced registration fee and are exempted from payment of any court fees in relation to any proceeding under the PPVFR Act.[122] The form for registration of a farmer's variety is only four pages long. It is designed precisely to be accessible to those without specialized knowledge or resources.[123] This is a relative strength of the Indian system compared to the American and European systems, because it incentivizes the production of new plant varieties by large entities and individual persons alike.

3. Duration of Protection

Duration of protection means the length of time for which a breeder may obtain protection for a plant variety under the three regimes. Duration of protection is an important consideration for breeders.[124] Table 2 cleanly summarizes the durations of the forms of protection available under the three regimes. Certain observations are apparent. While the EU offers the longest terms of protection, the US offers a relatively shorter term of protection, and India offers the shortest duration.

Table 2	
Form of Protection	Duration (years)
US Utility Patent	20
US Plant Patent	20
US Plant Variety Protection	20, or 25 for vines and trees

[122] HANCHINAL & GANESH, *supra* note 79, at 79.

[123] *Application for Registration of Farmers' Variety*, PVPFRA , farmervariety2013.pdf (plantauthority.gov.in) (last visited Nov. 4, 2022).

[124] *About: Why We Patent Seeds*, BAYER VEGETABLES, https://www.vegetables.bayer.com/us/en-us/about/why-we-patent-seeds.html (last visited Nov. 25, 2022) (noting that vegetable varieties take between 8 and 12 years to develop, and that intellectual property allows for recoupment of development cost).

EU Plant Variety Rights	25, or 30 for certain varieties[125]
India Plant Breeders' Rights	15, or 18 for vines and trees

4. Limitations on Protection

Limitations on protection results in exceptions or carve-outs which negate the enforceability of the plant IP right in question. The US system places the fewest limitations on protection, while the EU provides a moderate number of exceptions, and the Indian system contains the greatest limitations.

a. Enforcement

A common limitation on the enforceability of a plant IP right is that a breeder may not enforce their right against farmers who save harvested materials for future commercial use as propagating material. The Indian and European systems provide uniquely strong exceptions for farmers, whereas the American system provides no such exceptions for seed-saving, except in the case of plant variety protection. Therefore, the European and Indian systems significantly limit the scope of protection available to breeders. After all, a significant portion of plant breeding can be assumed to be geared towards an agricultural market. The European system does this through its relatively restricted seed-saving exception (which member states may opt out of), whereas India goes further in offering a mandatory exception for farmers who save seed.

Although this may be a strength from the normative perspective of Indian policymakers who sought to ensure rights for farmers, it is questionable whether securing these rights is worth the erosion of protection offered to breeders. For example, breeders and farmers are usually engaged in separate businesses, and intellectual property protection is generally more valuable to breeders, as they are in the business of developing new varieties. Farmers, on the other hand, are in the business of cultivating varieties. Allowing farmers to save seed and then subsequently earn protection for varieties under the more relaxed standards for farmers' varieties may encourage them to exploit the research and development activities of breeders.[126] Given that a fundamental reason for extending IP protection to plants is their unique capability to self-replicate, enabling farmers to engage in self-serving exploitation undermines this fundamental reason for extending protection in the first place, as breeders do not set out to work for farmers in this regard.

Another key limitation to plant IP obtained under the Indian and European systems (and the American system for PVP) is that they are necessarily non-enforceable against varieties that are not considered essentially derived. This

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[125] *See* Commission Regulation 2021/1873, 2021 O.J. (L 220) 86 (EU) (providing for a term of thirty years for asparagus, and "the species groups flower bulbs, woody small fruits and woody ornamentals").

[126] *See, e.g.,* Monsanto Co. v. Bowman, 657 F.3d 1341, 1347 (Fed. Cir. Sept. 21, 2011) (providing an illustration of the type of commercial exploitation that could be allowed if seed saving practices are not treated as infringement).

makes them relatively more limited than the patent forms of IP protection offered under the American system. In other words, because PVP, PBR, and PVR are only enforceable against essentially derived varieties, breeders can use technology to "breed around" the concept of essentially derived varieties in order to obtain a particularly innovative quality of a protected variety.[127] Additionally, the European and Indian systems both contain research exceptions, and the European system in particular exempts various categories of non-commercial behavior and provides through the doctrine of exhaustion that a PVR cannot be enforced against a customer who resells propagating material purchased from a right holder.

Therefore, under the European and Indian regimes, where utility patent protection has not been extended to essentially biological processes, breeders may feel that their rights offer them little protection due to the rapidity with which copycat varieties can now be produced. Under the American regime, on the other hand, breeders can obtain utility patent protection for their varieties, and this protection carries no exception for derived varieties which are not defined as essentially derived. This means that the American approach, in providing multiple forms of plant IP, provides breeders with the flexibility to choose whether they want the more limited PVP or the more robust patent forms of protection.

b. Overlapping Protection

Overlapping protection occurs when a creation is protected by multiple forms of IP at the same time. The issue of overlapping protection is highly relevant in many fields of IP law, and plant IP is no exception.[128] It is included here because providing breeders with only one form of protection while excluding them from patentlike forms is essentially a limitation on protection. The American system is unique amongst the three regimes because it allows for relatively more overlapping protection between its frameworks for plant patents, PVP, and utility patents. The European and Indian systems are more hesitant to extend overlapping protection.

Overall, the overlapping and heterogeneous nature of the American regime is a strength because it more effectively accommodates the concerns of the industry that it seeks to incentivize. An American breeder can consider the nature of their plants and competitive threats to decide whether, for instance, to seek protection under plant patents for efficiency or utility patents for strength, as the former only extends protection to a particular variety. An Indian or European breeder does not have this luxury. And of particular importance, only American breeders can obtain overlapping protection.

There are several examples of overlapping protection under the American system, and it seems that no legal mechanisms exist to prevent or punish

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[127] Maliata Wanga et al., *Opportunities and Challenges of Speed Breeding: A Review*, 140 PLANT BREED. 185, 186–94 (2021).

[128] Viva R. Moffat, *Mutant Copyrights and Backdoor Patents: The Problem of Overlapping Intellectual Property Protection*, 19 BERKELEY TECH. L. J. 1473, 1474–1521 (2004).

breeders for pursuing overlapping protection.[129] This provides breeders with flexibility in seeking protection, because it creates opportunities for maximizing the utility of their protection. The best example of this is that a breeder can establish a utility patent over a given genetic expression within a broad set of plants, and then later on, apply for additional forms of protection for particular varieties that they derive from the protected invention, thus allowing a breeder to "extend his or her exclusivity on the technology."[130] Another example is that a breeder could first establish protection over a given variety, such as through a plant patent or a plant variety protection certificate, and then later establish utility patent protection over "methods of breeding and growing the variety…to block competitors from exploiting the breeder's exception and saved seed exception of his or her PVP certificate."[131] European and Indian breeders must instead suffer from the copycat variety problem discussed above.

Therefore, overlapping protection is a significant, and likely the single most important, distinguishing characteristic of the American approach, which separates it from the European and Indian approaches. Overlapping protection, as shown above, can significantly erode limitations on individual forms of protection and can be used to perpetuate protection over a given variety. Overlapping protection therefore acts as a sort of multiplier on the robustness or strength of protection offered under the American regime. This is a big strength for the American system, as the strength of overlapping protection can be highly motivational to breeders.

However, there is a partial functional equivalent to American overlapping protection in plant IP on the grounds that processes for genetically engineering plant varieties are patentable in Europe. But this is different from offering a breeder protection for a new variety, because in order for a breeder to obtain a European utility patent that could offer de facto protection for their variety, they would need to also invent a new process for engineering the variety. Highly sophisticated breeders potentially are capable of this, but most likely aren't. Regardless, the European utility patent is of little use to all except the most sophisticated of plant breeders, which is why the American system offers more accessible overlapping protection.

B. Interim Conclusions

Table 3 condenses the preceding comparative analysis. The main conclusion to draw from Table 3 is that, relatively speaking, the US offers breeders the most protection with the least limitations, whereas Europe charts a middle course and India offers the least protection. However, under the Indian regime, protection

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[129] *See* Daniel J. Knauss et al., *Protecting Plant Inventions*, 11 LANDSLIDE 42, 47 (2019) (explaining the permissibility of overlapping protection under the American regime, and providing examples of overlapping protection, such as a variety of "*Guzmania Lingulata*" which was simultaneously protected by a plant patent and utility patent, and a variety of corn which was simultaneously protected under a utility patent and a plant variety protection certificate).

[130] *Id.* at 47.

[131] *Id.*

is the most accessible, both financially and in terms of compliance with requirements for protection.

Table 3

Attribute	US	EU	India
Legal Structure	Medium financial barriers, greatest technical barriers.	Greatest financial barriers, medium technical barriers	Lowest financial and technical barriers.
Categories of protection	Greatest degree of choice between categories	Lowest degree of choice	Medium degree of choice
Duration of protection	Medium	Longest	Shortest
Requirements for protection	Varies from most cumbersome to on par with EU	Medium	Least cumbersome
Limitations on protection	Least limitations, most overlapping protection	Medium-high, overlapping protection narrowly possible	Most limitations, overlapping protection narrowly possible

IV. BROADER CONNECTIONS AND RECOMMENDATIONS

This section establishes a connection between plant IP and economic development. It does this by discussing how plant innovation (which plant IP is intended to incentivize) is connected to crop yields, climate change, and food security, all of which affect economic development. Then, it offers recommendations for reforming plant IP so that the law can better incentivize plant innovation, and ultimately, promote societal and economic development. These recommendations are rooted in the preceding comparative analysis.

A. Broader Connections: Why Plant Innovation Matters for Contemporary Economic Development

1. Plant Innovation Improves Crop Yields

Plant breeders improve crop yields by designing innovative varieties that provide a greater bounty, even in the face of less desirable growing conditions. Plant innovation in the 20th and 21st centuries produced massive gains in agricultural productivity.[132] For example, American corn yields increased by a factor of ten, while soybean yields increased from under 15 bushels per acre to over 50 bushels per acre between 1930 and 2021.[133] The U.N. Food and Agriculture Organization asserts that plant breeding is responsible for roughly 50 percent of worldwide agriculture productivity gains over the last 100 years.[134] It highlights cassava yields in Thailand, which rose 64.7 percent between 1990 and 2007.[135]

Economic analyses have provided that the plant breeding activities alone contributed to 89 percent of the gain in corn yields experienced in the United States between 1930 and 1980, 90 percent of the gain in soybeans, 67 percent of cotton gains, and 50 percent of wheat gains.[136] Overall, there is strong academic consensus within the fields of agriculture policy and economics that plant breeding has played a significant role in the improvements in crop yields that the world has experienced since the turn of the 20th century.[137]

2. Crop Yields Drive Economic Development

a. Increased Yields Boost Developing Economies and Especially Local Agrarian Communities

The UN FAO asserts that plant breeding helps drive economic development through keeping marginal agribusinesses economically viable, and that this contributes to increased total revenues and ultimately, increased gross domestic product.[138] This is in part due to increased yields. For many developing countries, bolstering marginal agribusinesses is critical to ensuring economic growth and stability for local agrarian communities. India is a prime example, as agriculture represents 23 percent of GDP, and is the primary "source of livelihoods", with 72 percent of the rural population depending on agriculture as their primary source of income and 82 percent of farmers being "small" or

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[132] *See* JANIS et al., *supra* note 11 (describing increases in American corn yields); Econ. Rsch. Serv., *Improved Seed is a Major Contributor to Crop Yield Gains and Agricultural Productivity*, USDA https://www.ers.usda.gov/webdocs/publications/42517/13599_aib786d_1_.pdf?v=204.9 (last visited Nov. 13, 2023).

[133] Econ. Rsch. Serv, *supra* note 132; Jim Barrett, *Corn and Soybean Production Up in 2021*, USDA (Oct. 12, 2021), https://www.nass.usda.gov/Newsroom/printable/2021/10-12-2021.pdf.

[134] Glob. P'ship Initiative Plant Breeding Capacity Bldg., *Plant Breeding Impacts and Current Challenges*, FOOD AGRIC. ORG., https://www.fao.org/3/at913e/at913e.pdf#:~:text=Plant%20Breeding%20is%20responsible%20for%20about%2050%25%20of,from%20better%20crop%20management%20%28e.g.%2C%20fertilization%2C%20irrigation%2C%20weeding%29 (last visited Nov. 13, 2023).

[135] *Id.* (noting cassava is a potent example because it is relied upon as a calorie-dense food source in developing countries).

[136] ECON. RSCH. SERV., *supra* note 129.

[137] *See generally*, Jikun Huang et al., *Enhancing the Crops to Feed the Poor*, 418 NATURE 678, 678 (2002); Joao Silva Dias, *Plant Breeding for Harmony Between Modern Agriculture Production and the Environment*, 6 J. AGRIC. SCI. 87, 87 (2015).

[138] FOOD AGRIC. ORG., *supra* note 134.

"marginal".[139] To boost agricultural output in these communities is to boost their economies, and the national economy, outright.

A review of the literature on agriculture and economic development reveals that "[a]gricultural R&D and its capacity to produce more productive [i.e., higher yielding] technologies are the heart of long-run agricultural growth."[140] The relationship between yield and development has been observed on a local level, for example, in an econometric analysis of maize production in Malawi, which was plagued by "chronically law maize yields", it was observed that ". . . in Malawi the. . . technological change that is necessary to sustain a growing population can only be achieved through the adoption of seed. . . technology."[141]

However, while plant breeding has made impressive strides in cereals and grains, there is far more progress to be had in fruit, vegetables, and pulses, which are key to developing agrarian economies in countries such as India.[142] This leaves considerable room for plant innovation to continue making an impact in developing countries, in part through yield gains.

b. Increased Yields Free Up Labor for More Productive Activities

One of the key trends in agriculture for developed countries such as the US and the EU member states has been the extent to which farms, and farmers, are becoming scarcer, while farm efficiency and size have improved so as to offset this reduction in labor.[143] This was most pronounced throughout the 20th century.[144]

Something about this trend that goes undiscussed is the economic effect of moving labor away from farming and into other activities. In part because of yield productivity increases attributable to plant breeding, workers who would have once spend their lives in agriculture are now able to devote their labor to more productive activities, such as working in manufacturing or practicing medicine. One can see this occurring in labor data, as between 1992 and 2002, the US lost 20 percent of its farm worker jobs, but added jobs for nurses, financial planners, and lawyers at rates of 28 percent, 78 percent, and 24 percent respectively.[145] The secondary effects of this have not been empirically studied, but it is safe to assume that by moving labor out of commodity production and into the provision of more complex services, economic growth is achieved not

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[139] *India at a Glance*, FOOD AGRIC. ORG., https://www.fao.org/india/fao-in-india/india-at-a-glance/en/ (last visited Feb. 13, 2023).

[140] Jean-Jacques Dethier & Alexandra Effenberger, *Agriculture and Development: A Brief Review of the Literature*, 36 ECON. SYS. 175, 184 (2012).

[141] Melinda Smale et al., *Maize of the Ancestors and Modern Varieties: The Microeconomics of High-Yielding Variety Adoption in Malawi*, 43 ECON. DEV. CULTURAL CHANGE 351, 352 (1995).

[142] *Id.*

[143] Econ. Rsch. Serv., *Farming and Farm Income*, USDA, https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/farming-and-farm-income/ (last visited Feb. 13, 2023).

[144] *Id.*

[145] Diamond, *supra* note 22, at 96.

only directly, but also indirectly through the ways in which these complex services relate to other areas of the economy.

3. Plant Innovation Enables Climate Change Adaptation and Mitigation

Climate change and related forms of environmental degradation are more relevant to our civilization now than at any point in human history. Climate change threatens to destabilize critical systems that uphold contemporary society, and agriculture is one of these critical systems.[146] Emissions from burning fossil fuels and other activities release gases that contribute to a greenhouse effect in which solar radiation becomes increasingly trapped within the Earth's atmosphere, causing increased baseline temperatures.[147]

Agriculture, horticulture, and food production in general produce carbon, methane, and other greenhouse gas emissions which contribute to the greenhouse effect. They also often involve the conversion of natural ecosystems into terraformed agricultural production zones, which reduces natural greenhouse gas absorption.[148] The greenhouse effect produces undesirable impacts on the world's ecosystems, such as increased frequency of drought, flooding, wildfire, increased variation in temperatures, and rising sea levels.[149] Together, these effects threaten society by destabilizing supply chains, disrupting established population centers, and in numerous other ways. All of this is common knowledge and well established throughout various fields of study.

Plant innovation can help the world mitigate and adapt to climate change. In terms of mitigation, plant innovation can improve the efficiency of agricultural land and resource use, with the effect of reducing net carbon emissions. In terms of adaptation, plant innovation can help our food production system operate despite disruptions from climate change.

Plant innovation can help mitigate climate change through driving land use efficiency. Breeding varieties with more efficient yields, such as breeding for greater yields or nutritional compositions, may allow for greater yields per square acre of land put to agricultural use.[150] To the extent that climate change will make some traditionally-farmed areas unproductive and other, undeveloped areas relatively more productive, plant innovation allows for the development of climate-resistant varieties that can keep traditionally-farmed areas

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[146] *See* John Gowdy, *Our Hunter-Gatherer Future: Climate Change, Agriculture and Uncivilization*, 115 FUTURES 1, 1 (2020) (arguing that a 3-4 degrees Celsius increase in global temperatures would render agriculture, and ultimately the contemporary structure of civilization, impossible to maintain).

[147] *See* Mark Lynas et al., *Greater than 99% Consensus on Human Caused Climate Change in the Peer-Reviewed Scientific Literature*, 16 ENV'T. RES. LETTERS 1, 1 (2021) (conducting a meta-analysis of 3,000 scientific papers and concluding that manmade climate change exists).

[148] PRADEEP KURUKULASURIYA & SHANE ROSENTHAL, CLIMATE CHANGE AND AGRICULTURE: A REVIEW OF IMPACTS AND ADAPTATIONS 3–4 (2003).

[149] *Id.*; Andrew Moore, *Climate Change is Making Wildfires Worse - Here's How*, NC STATE UNIV. (Aug. 29, 2022), https://cnr.ncsu.edu/news/2022/08/climate-change-wildfires-explained/.

[150] Karavolias et al., *supra* note 18, at 14.

commercially viable. This can alleviate the need for developing other areas for agricultural use in a way that helps to mitigate climate change. This development, typically seen through slash-and-burn deforestation, is an enormous contributor to climate change.[151] For example, if drought-resistant varieties can allow marginally-viable agricultural lands to remain viable despite an increased frequency of drought, then the need to clear forests and drain wetlands may be reduced.

Innovative varieties may be designed to reduce intensity of resource use by agriculture.[152] Varieties bred to be naturally resistant to disease, pests, or drought may require fewer chemical applications, irrigation, and soil management activities, all of which contribute to environmental degradation. This effect may also be experienced through breeding more efficient varieties that require less land per unit of yield output. In short, by driving efficiencies in land and resource use, innovative varieties can help reduce carbon emissions and preserve natural mechanisms by which carbon is absorbed.

Innovative varieties may also help us to adapt to the increasingly intense effects of climate change. For example, water shortages due to increased frequency of drought may be alleviated through drought resistant varieties that require less irrigation and therefore less water use.[153] Increased frequency of natural disasters may lead to decreased yields, but innovative varieties can provide higher yields across the board to offset this unpredictability.[154] Increased flooding may affect crops that thrive only in freshwater, but innovative varieties may be designed for increased tolerance to saltwater.[155] Climate change may increase the frequency of diseases afflicting crop populations, but innovative varieties can be designed around this problem as well.[156]

4. Climate Adaptation and Mitigation Promote Economic Development

In short, climate change adaptation and mitigation efforts will provide an economic return on investment because the resulting benefits should outweigh the costs of inaction. The costs of inaction with respect to climate change are diverse and far-reaching. Rising sea levels, an increase in severity and frequency of natural disasters, more extreme temperatures, and changes in precipitation patterns are all anticipated to occur and will likely occur more severely given no

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[151] *Deforestation 101: Everything You Need to Know*, WORLD ECON. F. (Oct. 11, 2022), https://www.weforum.org/agenda/2022/10/deforestation-101-everything-you-need-to-know/.

[152] *See* Karavolias et al., *supra* note 18, at 3 (explaining that gene editing research on rice suggests opportunities for water use efficiency).

[153] *Id.*

[154] *Id.* at 11–12.

[155] *Id.* at 3.

[156] *Id.* at 6.

effort on mitigation and adaptation.[157] These phenomena will impose direct and indirect economic costs on society.[158] The direct costs are apparent, for example, the damages from hurricanes, flooding, drought, wildfires, and sea reclamation all stand to increase.[159] However, there are numerous indirect costs as well, such as replacing infrastructure, relocating populations, disrupting production of goods and services, raising the cost of financial products like insurance, and frustrating consumption patterns like in tourism.[160] These direct and indirect costs threaten to raise prices, reduce individual incomes, and threaten overall quality of life, which could lead to a vicious circle that causes additional negative externalities.[161]

Within the context of agriculture and plant innovation, many of the ways in which mitigation and adaptation can be achieved were explained above. In terms of economic impact, however, we are fortunate to have already invested heavily in plant breeding infrastructure over the course of the past several decades. This makes plant innovation a prime area for mitigation and adaptation because unlike capital intensive, novel investments like wind and solar developments, we already have the critical infrastructure necessary to pursue mitigation and adaptation through plant breeding. All that is needed are stronger incentives to encourage plant breeders to invest more heavily in breeding activities that contain positive climate externalities.

5. Plant Innovation Bolsters Food Security

Food security is also an important issue. Ancient, modern, and contemporary history is riddled with examples of famine and malnutrition. Today, much of the world continues to grapple with intense food security issues.[162] Food secure jurisdictions may only deal with marginal problems related to hunger, but that does not mean that these problems should be minimized or ignored. Some jurisdictions are food secure at present, but do not have the capacity to withstand major shocks to food supply or to self-sufficiently produce their own food.[163] Other jurisdictions, while maintaining a relatively secure food supply, fall short in terms of malnutrition.[164] In other words, some jurisdictions are able to meet their population's caloric needs but not their nutritional needs. And of course, some jurisdictions have little or no food security at all, and in these

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[157] *See* CTR. INTEGRATIVE ENV'T. RSCH., *The US Economic Impacts of Climate Change and the Costs of Inaction: a review and assessment by the Center for Integrative Environmental Research (CIER) at the University of Maryland,* U. MD. 1, 3 (2007), https://rosap.ntl.bts.gov/view/dot/17359.

[158] *Id.*

[159] *See generally id.*

[160] *Id.* at 4.

[161] *Id.* at 6.

[162] *See* WORLD FOOD PROGRAMME, *supra* note 5 (detailing how parts of Africa, Asia, and the Middle East still grapple constantly with insufficient calorie consumption).

[163] *What Are Food Crises and How Many People Are Affected by Them?*, WORLD ECONOMIC FORUM, (May 25, 2021), https://www.weforum.org/agenda/2021/05/global-food-crises-report-conflict-2021/.

[164] *See* WORLD FOOD PROGRAMME, *supra* note 5 (detailing how many countries suffer from undernutrition).

places, malnutrition, starvation, and food shortages are widespread and common.

Plant innovation addresses food security by providing and disseminating genetic expressions that help us produce more food, and more nutritious food. There has been a strong showing in the literature that plant innovation, particularly gene editing technologies like CRISPR, can facilitate a more robust response to food insecurity.[165] Additionally, the future development of gene editing technologies allows for the more rapid development and dissemination of varieties specialized for particular environments or situations.

The traditional view of plant innovation within the context of food security was that through producing higher-yielding varieties and encouraging their adoption, global food security would be bolstered by increases in yield throughout the globe.[166] This traditional view was common among proponents of the "Green Revolution," who sought to export modern agricultural techniques, such as the use of hybrid or genetically-modified plant varieties, to developing countries. The idea was that these countries could become more food secure by producing with greater efficiencies, especially yield efficiencies, through mechanized agriculture. In some highly food insecure jurisdictions, an overall increase in yields over a matter of years would still undoubtedly provide greater support to food security in those jurisdictions, as discussed above.

However, plant innovation has come far beyond breeding only for yield. Plant varieties can and have been designed to produce harvested materials containing particular nutrient and metabolic concentrations.[167] These varieties have the ability to address not only instances of famine or starvation, but also situations where food security is adequate in some respects, but malnutrition remains. The most famous instance of a variety capable of making a difference in such a way is "golden rice" which was bred to possess levels of beta-carotene that cannot be found in naturally occurring varieties.[168] This was intended to alleviate Vitamin A deficiency due to the human body's natural conversion of beta-carotene to Vitamin A. Vitamin A deficiency is common in areas with low food security and produces disastrous impacts on human health and development. Golden rice "contains up to 37 ug/g carotenoids, sufficient to fulfil half of daily vitamin A requirements with 60 g of uncooked rice."[169]

Innovative varieties can also be bred to reduce harmful nutritional qualities, such as reduced concentrations of starch in potatoes and cassava.[170] This form of plant innovation can improve health outcomes in food insecure jurisdictions, where populations tend to rely on cheap and easily available sources of calories,

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[165] Sang-Gyu Kim, *CRISPR Innovations in Plant Breeding*, 40 PLANT CELL REP. 913, 913–14 (2021).

[166] *See* Mohd Hamdan et al., *Green Revolution to Gene Revolution: Technological Advances in Agriculture to Feed the World*, 11 PLANTS 1, 1–2 (2022) (implying that the Green Revolution era of plant innovation largely consisted of yield improvements).

[167] Karavolias et al., *supra* note 18, at 14.

[168] *See generally,* Kettenburg, *supra* note 8, at 1470.

[169] *Id.*

[170] Karavolias et al., *supra* note 18, at 14.

such as starchy foods.[171] If such varieties can be bred to contain more nutritional qualities and less harmful qualities, food insecure populations can rely on such varieties, resulting in positive effects on health outcomes.[172]

Additionally, plant varieties could be designed to respond to particular instances of mass starvation or malnutrition. This is because innovative breeding technologies allow for the design of plant varieties that are better suited for particular microenvironments in which there is high food insecurity. This is feasible due to the rapidity with which plant innovations are occurring due to new breeding technologies such as CRISPR.[173] For example, breeders could design and bring to market a variety of cassava specifically designed for an instance of famine in Africa, while developing a variety of wheat that is well-suited to address famine in Afghanistan. Such technologies will also allow for the production of new varieties in a more compressed timeline, which increases the potential impact varieties can have in response to instances of malnutrition or starvation.

6. Food Security is Key to Economic Development

Food security is important to economic development because food is a core human need. Academics such as Rawls and Maslow characterize food as being a “primary good” or a “physiological need.”[174] Economists such as Diamond argue that the unrestrained forces of innovation can alleviate the amount of time, energy, and other resources that people have to put into satisfying core needs such as hunger.[175] This alleviation allows people to access greater “information, free choice, and mental acuity” which allows them to work towards a “wid[er] range of life plans” and more “challenging and meaningful projects”.[176] These mechanisms, in turn, produce “paths to human flourishing”.[177]

This has been shown empirically, as economists have found that as GDP increases, food security improves at a disproportionately lower rate, which suggests that food insecurity drives economic development more than economic development drives food insecurity.[178] Indeed, improvements in a country’s food security can lead to progress in terms of “life expectancy, total employment, and

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[171] *See* Joseph Mutuku et al., *The Biofortification Continuum: Implications for Food and Nutrition Security in Developing Countries*, 20 AFR. J. FOOD AGRIC. NUTRITIONAL DEV. 15317, 15318–19 (2020) (arguing that plant innovation, specifically nutrient enrichment, can have enormous impacts on the developing world, and that this renders cassava an ideal target for plant innovators).

[172] *Id.*

[173] *See* Kim, *supra* note 165, at 913 (detailing a host of CRISPR plant innovations that have occurred within ten years of the technology’s discovery).

[174] Diamond, *supra* note 22, at 43.

[175] *Id.* at 44–45.

[176] *Id.*

[177] *Id.*

[178] Marie T. Ruel et al., *Nutrition-Sensitive Intervention and Programmes: How Can they Help to Accelerate Progress in Improving Maternal and Child Nutrition?*, 382 LANCET 536, 538 (2013).

poverty. . . ."[179] One reason for this may be that food insecurity acts as a limit on the extent to which an economy can invest in human capital.[180] Overall, "high rates of malnutrition [due to food insecurity] can lead to a loss in GDP of as much as 4 to 5 percent."[181] The World Economic Forum summarizes the issue well by stating that food security matters in part because it affects "practically all aspects of an economy. . . ."[182]

Moreover, climate change stands to make food insecurity worse. This is because climate change has already depressed global yields of key food staple crops such as wheat, corn, and soybeans.[183] Increased frequency of natural disasters may make food supply chains bend, or even break. An example of this in 2022 is the drought in the Midwestern and Southern United States which has choked off grain exports via the Mississippi River.[184] Some agricultural lands may be rendered useless by flooding. Other extreme events, like wildfires, tornados, derechos, and increased variation in temperatures and precipitations all stand to make yields less predictable, which in turn results in higher food prices or shortages.

This paper argues that because plant IP is a tool by which society can incentivize plant innovation, and because plant innovation is part of the solution to issues like climate change, food insecurity, and crop yields, that plant IP should be reformed to increase its capacity as an incentive such that human social and economic development can be more robustly pursued.

B. Recommendations: How Plant IP Can Better Incentivize Innovation to Bolster Contemporary Economic Development

Plant IP is intended to incentivize the production of new varieties, and there is good evidence that it has had success as an incentive.[185] However, plant IP should seek to offer more than just a virtual monopoly on the use of a new variety. It should offer incentives that encourage the development of useful varieties. This is not to suggest that utility is or should be a requisite for protection, only that protection should carry with it some sort of advantages when protection is

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[179] Nur Marina Abdul Manap & Normaz Wana Ismail, *Food Security and Economic Growth*, 2 INTL. J. MOD. TRENDS SOC. SCI. 108, 108 (2019).

[180] Maximo Torero, *Food Security Brings Economic Growth — Not the Other Way Around*, IFPRI (Oct. 15, 2014), https://www.ifpri.org/blog/food-security-brings-economic-growth-not-other-way-around.

[181] *Id.*

[182] Keith Breene, *Food Security and Why it Matters*, WORLD ECON. F. (Jan. 18, 2016), https://www.weforum.org/agenda/2016/01/food-security-and-why-it-matters/.

[183] Toshichika Iizumi et al., *Crop Production Losses Associated with Anthropogenic Climate Change for 1981-2010 Compared with Preindustrial Levels*, 38 INTL. J. CLIMATOLOGY 5405, 5405 (2018).

[184] Jeff Masters & Bob Henson, *Mississippi River Record-Low Water Levels Ease Some, but Long-Term Forecast is Dry*, YALE CLIMATE CONNECTIONS (Oct. 24, 2022), https://yaleclimateconnections.org/2022/10/mississippi-river-record-low-water-levels-ease-some-but-long-term-forecast-is-dry/.

[185] Jorge Fernandez-Cornejo, *The Seed Industry in U.S. Agriculture: An Exploration of Data and Information on Crop Seed Markets, Regulation, Industry Structure, and Research and Development*, USDA, vii (2004).

sought for varieties that are particularly useful for important issues. Additionally, it should offer breeders stronger protections in order to promote investment in research and development.

Table 3 provides succinct conclusions resulting from this paper's comparative analysis. This section explains how these conclusions shape useful recommendations for reforming the plant IP systems analyzed above. Specifically, this section offers four recommendations that are intended to increase the extent to which plant IP incentivizes breeders to produce varieties that are useful for promoting social and economic development. Through doing so, plant IP can be made more impactful.

1. Adopt Legal Structure that Incentivizes Targeted Innovation

Table 3 shows how aspects of legal structure such as testing burden and fees can represent a barrier to plant breeders. Plant IP can better address development issues by reforming these aspects of legal structure to better incentivize innovation useful in addressing these issues. Examples of such innovations are discussed in the "Broader Connections" section.

One way this could be accomplished is to impose higher fees on wealthy commercial breeders, but to simultaneously provide that such fees may be waived for varieties which possess qualities that are useful for promoting economic development and addressing development related issues. Alternatively, higher fees could be used to fund subsidies for breeders who seek protection for useful, innovative varieties.

Within the American system, another way that this could be accomplished is to modify testing burden so that breeders who seek protection for useful, innovative varieties would be relieved of their burden to prove conformity with requirements for protection. A fee-subsidy program could be designed so that breeders pay slightly increased fees across the board to rest the testing burden on the state for breeders seeking protection for particularly useful and innovative varieties. These reforms could serve to make plant intellectual property more accessible to all breeders, and ultimately, more of an incentive for plant innovation.

2. Develop Limitations on Protection That Take Climate and Food Issues Seriously

Table 3 also shows that plant IP systems vary considerably in terms of limitations on protection. One way that these systems can be reformed is to provide for limitations on protection that more directly contemplate important development issues like climate change and food security. This can be accomplished by providing special limitations on breeders who sit on useful and innovative varieties and do not disseminate them sufficiently.

Intellectual property law often contains exceptions to protection for extenuating social circumstances. For example, patent law might provide that in instances where additional production of a patented good is required in order to provide for the national defense, patent protection might be suspended if it is suppressing production to an extent which threatens national security.

Similarly, plant IP law should contain mechanisms in this regard, that extend to climate risks and humanitarian situations like famine. It is important that protection for useful varieties is not sought merely to hold up the social benefits of such varieties to extract a return on investment. But it is simultaneously important to never disincentivize an innovator by denying them returns. Therefore, such exceptions must be narrow in scope and specific to particular circumstances. Expanded exceptions to protection on the grounds of promoting useful production can therefore allow IP law to operate as a disincentive to breeders who seek to take advantage of protection without supplying society with its expected benefits from extending protection in the first place.

However, intellectual property law should, above all else, seek to incentivize the production of new, innovative varieties. To this end, jurisdictions like India and Europe should consider reducing their limitations on protection, such as through weakening exceptions for seed saving, farmers' varieties, and essentially derived varieties. Although there are important policy considerations for why these jurisdictions may want to preserve these limitations to some extent, weakening them could certainly improve the incentive value of their approaches to plant IP.

3. Give Breeders More Choice and Flexibility Through Categories of Protection

Table 3 and its associated analysis shows that plant IP regimes vary considerably in the amount of flexibility or choice they offer to breeders who seek protection for new varieties. Jurisdictions like the European Union which offer virtually no choice to breeders between various categories of protection may not be incentivizing breeders to their fullest extent, because breeders that can obtain multiple, or even overlapping forms of protection across several categories have stronger incentives to innovate because they can pursue more complex IP protection strategies.

For example, Europe could liberalize its prohibition on the utility patentability of plant varieties to allow breeders to also obtain utility patent protection, like in the US. This might encourage more European breeders to invest more in their breeding activities and encourage more breeders from other jurisdictions to increase their breeding activities within Europe. This increase in breeding activity could produce more protectable varieties, and ultimately, more varieties that are useful for addressing the key drivers of economic development discussed above.

4. Enhance Duration of Protection for Innovative Varieties

The comparative analysis above also showed big differences between jurisdictions in terms of the duration of protection offered by each system. Jurisdictions like India, which offer materially shorter durations of protection, may not be fully incentivizing plant breeding activity that could be useful for addressing issues relevant to contemporary economic development. Offering shorter durations of protection gives breeders a shorter window of opportunity for recouping the costs associated with developing the variety, which can be discouraging to some breeders. Jurisdictions can incentivize breeders to take greater risks in developing useful and innovative varieties by giving them longer durations of protection that maximize probability of recoupment.

One way that jurisdictions can accomplish this is to offer breeders enhanced durations of protection for varieties that are particularly useful for development purposes. For example, a jurisdiction might provide that breeders who develop varieties that possess certain qualities, like drought resistance or biofortification, can apply for extensions on their protection upon a showing that the varieties are being disseminated and used effectively in addressing food insecurity or climate change.

Alternatively, a jurisdiction might offer special, limited opportunities to breeders who quickly develop varieties fit for responding to certain situations. For example, a jurisdiction seeking to address a particular instance of famine in Afghanistan might provide that for the next ten years, any breeder who develops a variety especially designed for use in responding to the famine will receive an enhanced duration of protection for their variety. Of course, this would need to be subject to rules which ensure that the breeder is appropriately disseminating this variety in order to achieve the desired social outcomes.

V. CONCLUSION

In conclusion, this article conducted a comparative analysis of the American, European, and Indian approaches to plant intellectual property, which yielded several similarities, differences, strengths, and weaknesses between the regimes. Then, it justified the need for reforming plant IP to better promote plant innovation by showing the connection between plant innovation and key issues relevant to contemporary economic development. Finally, it offered recommendations for reforming plant IP to better promote plant innovation in light of conclusions yielded from the comparative analysis.

Overall, this paper has made an original contribution to the literature by conducting a novel comparative analysis of plant IP, by theorizing broader connections between plant IP and the issues relevant to contemporary economic development, and by offering tangible recommendations which serve to increase plant IP's capacity to inspire innovation that drives societal and economic development.