

Science & Society

Plant Genetic Resources: Needs, Rights, and Opportunities

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Technological advances allow us to tap into genetic resources to address food and nutritional security in the face of population growth, urbanization, climate change, and environmental degradation. It is vital, particularly for developing countries, to ensure that the policy framework regulating access and use of genetic resources keeps pace with technological developments.

The Need for Genetic Resources

One of the grand challenges facing society in the 21st century is to produce sufficient nutritious food in the face of climate change, population growth, and rapid urbanization, and to do so in an environmentally sustainable manner. The United Nation's Sustainable Development Goal No. 2ⁱ explicitly recognizes the pivotal role that genetic diversity plays for food security, nutrition and sustainable agriculture. The genetic diversity of crops constitutes plant **genetic resources** (see [Glossary](#)) that provide the basic building blocks to improve the productivity, resilience, and nutritional composition of crops.

Enormous advances have been made for high-throughput systems to genotype and phenotype genetic resources, and these have profound implications for the utilization of genetic diversity of crops [1]. However, the policy framework regulating access and use of genetic resources

has received less attention by the plant science community. Here we outline the policy framework regulating access, distribution, and benefit-sharing agreements of plant genetic resources, and point to important policy implications of genomics and gene-editing technologies.

Who Has What Rights to Use Plant Genetic Resources?

Before 1993, plant genetic resources were regarded as global genetic goods, that is, available to anyone to use without restriction [2]. During the 1970s and 1980s, large public *ex situ* collections were created in response to concerns that the 'green revolution' of the 1960s was displacing crop diversity needed for continuous progress in plant breeding. At the same time, the **International Union for the Protection of New Varieties of Plants (UPOV) Convention** and the US Plant Variety Protection Act of 1970 granted exclusive intellectual property (IP) rights to plant breeders upon new commercial varieties [3] (Figure 1). The rise of recombinant DNA technologies in the 1980s further contributed to strengthen IP regimes for modified or altered germplasm through utility patents, a trend that has gained strength since the adoption of the **Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement** [4].

As a consequence, concerns grew that the framework for conferring exclusionary rights over new varieties and traits was being strengthened without protecting rights over older varieties and crop diversity *per se*. Many unprotected, older varieties were from developing countries, while IP protection of new plant varieties expanded in developed countries where seed companies were well positioned to profit from it [5].

In response to these concerns, new policy frameworks emerged to regulate access to, and use of, genetic resources [6]. The first legally binding intergovernmental agreement was the **Convention on**

Glossary

Access and benefit sharing: granting access to genetic resources must be subject to an assurance of the fair and equitable sharing of the benefits arising out of their use.

Clustered regularly interspaced short palindromic repeats/CRISPR-associated protein 9 (CRISPR/Cas9): the most widely used system for genome editing [10,11].

Convention on Biological Diversity (CBD): the CBD asserts the sovereign rights of nations to govern all biodiversity in their territory and under their control. This comes with an obligation to conserve biodiversity and to '...respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity...'^{vii}.

Genetic resources: defined in the CBD as 'genetic material of actual or potential value.' They constitute a subset of 'biological resources' (essentially all biotic components of ecosystems with actual or potential use or value for humanity). The CBD makes special provisions for access to genetic resources.

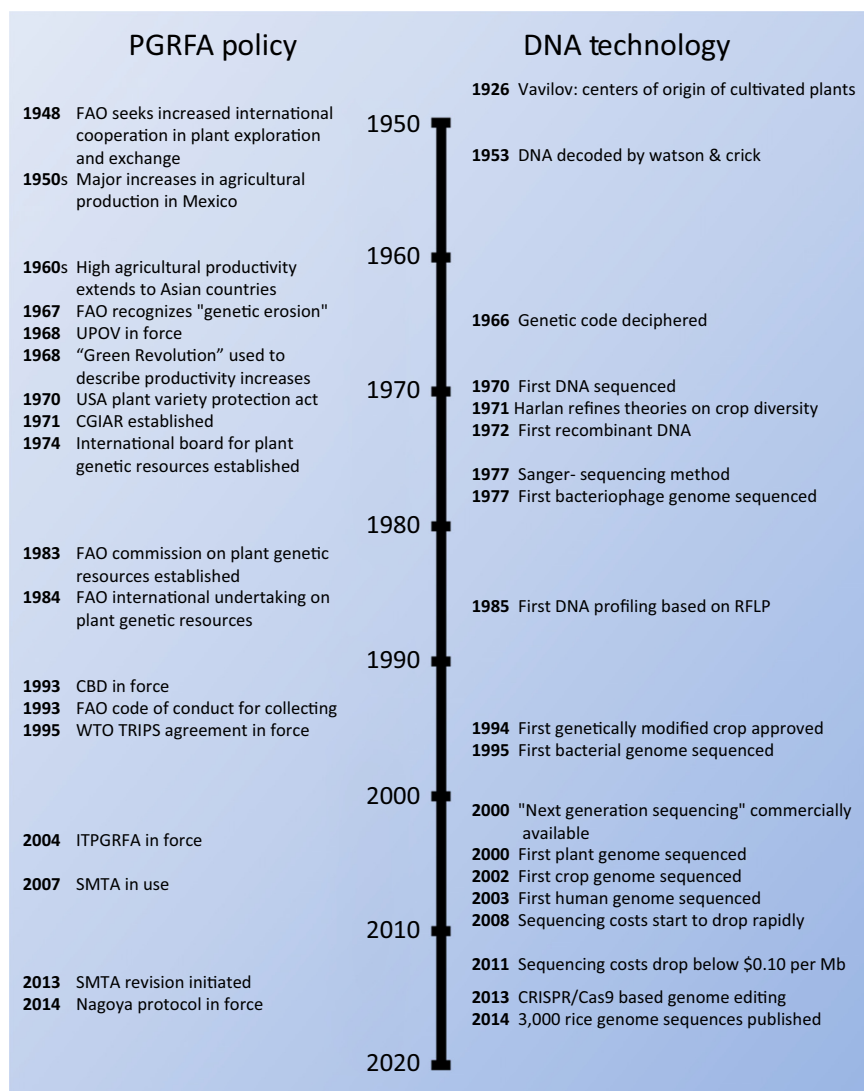
International Union for the Protection of New Varieties of Plants (UPOV) Convention: international convention for the protection of new varieties of plants, which established UPOV, the International Union for the Protection of New Varieties of Plants^{viii}.

IP right thicket: this term is used to describe the situation where an entity may be 'protected' by such a complex array of interacting IP rights controlled by multiple holders that its use becomes almost impossible and the intended benefits of IP rights protection are not realized.

Multilateral system: the Plant Treaty's multilateral system of access and benefit sharing; the component of the Plant Treaty that regulates access and benefit sharing for PGRFAs^{ix}.

Mutually agreed terms (MAT): a component of access and benefit sharing: any transfer of genetic resources must be subject to mutually agreed terms to ensure that benefits arising from the use of the genetic resources shall be shared in a fair and equitable way with the provider.

Nagoya Protocol: the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization sets core obligations for contracting parties for PIC and MAT, initially introduced in the CBD, and provides measures to support compliance with domestic legislation/regulatory frameworks set by the provider countries. Access, benefit sharing, and compliance measures also apply to traditional knowledge associated to genetic resources and to genetic resources held by indigenous and local communities with an established right to grant access to them. Specifically, the protocol requires countries to take appropriate measures



Trends in Plant Science

Figure 1. Parallel Timelines of Policy and Technology Developments. Abbreviations: CBD, Convention on Biological Diversity; CRISPR, clustered regularly interspaced short palindromic repeats; CGIAR, Consortium of International Agricultural Research Centres; FAO, Food and Agriculture Organization of the United Nations; ITPGRFA, International Treaty on Plant Genetic Resources for Food and Agriculture; PGRFA, Plant Genetic Resource for Food and Agriculture; RFLP, restriction fragment length polymorphism; SMTA, standard material transfer agreement; TRIPS, trade-related aspects of intellectual property rights; UPOV, International Union for the Protection of New Varieties of Plants; WTO, World Trade Organization.

Biological Diversity (CBD) in 1993. The CBD established **access and benefit-sharing** principles by which anyone wishing to access genetic resources from a country must obtain **prior informed consent (PIC)** from the relevant authorities and establish **mutually agreed terms (MAT)** specifying the conditions under which the resources can be used.

Subsequently, the **Plant Treaty** came into force in 2004. Designed to operate in harmony with the CBD, it was the first agreement to recognize farmers' rights. It established a **multilateral system** of access and benefit sharing regulated by a **standard material transfer agreement (SMTA)** that defines non-negotiable MAT.

to ensure that benefits are shared in a fair and equitable way with the communities concerned^x.

Plant genetic resource for food and agriculture (PGRFA): a term defined in the Plant Treaty as 'any genetic material of plant origin of actual or potential value for food and agriculture.' The term thus embraces a subset of genetic resources as defined in the CBD, and a subset of the potential uses of genetic resources.

Plant Treaty: the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The Plant Treaty's objectives are the conservation and sustainable use of PGRFAs and the fair and equitable sharing of the benefits arising out of their use for sustainable agriculture and food security. It urges member countries to take measures to protect and promote farmers' rights, including the right to protection of traditional knowledge related to PGRFAs and the right to participate in making national decisions on matters related to the conservation and sustainable use of PGRFAs. Countries may also choose to recognize other farmers' rights as appropriate and subject to national legislation^{xi}.

Prior informed consent (PIC): a component of access and benefit sharing; before granting consent to provide a sample of genetic resources and associated information, the provider must first be informed about the intended use of the material and information by the recipient.

Standard material transfer agreement (SMTA): the standard legal instrument for transferring PGRFAs under the multilateral system^{xii}.

Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement: an international instrument that establishes minimum standards for the protection of rights of different forms of intellectual property and connects such standards of protection to trade and the tools of trade enforcement. The terms of the TRIPS Agreement are binding upon all countries members of the World Trade Organization^{xiii}.

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