VALUATION AND OWNERSHIP OF GENETIC RESOURCES IN AGRICULTURE

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Summary

The free exchange of international germplasm and genetic resources in agriculture has been the operative procedure for all but the last 100 years of world history. The international exchange of germplasm has created a situation in which many crops are produced, primarily in areas distant from where they were first developed. Changes in global markets in the last twenty years have dramatically changed both the ownership

and the potential values associated with genetic diversity in agriculture. New ownership rules have increased economic values, while at the same time potentially disenfranchising former owners of genetic diversity.

This work reviews the current state of genetic resource ownership rules. It then assesses their potential value, first by developing theoretical models and then empirical models. A following section develops models of searches for valuable genetic traits. The last section discusses a number of issues for the future including the roles of the public and private sector, genetic use restriction technology, and how biotechnology may change the use and value of genetic resources. Issues of international ownership rules for agricultural genetic resources are still under debate and may not be quickly resolved. Overall, there are high economic values associated with germplasm and genetic resources in agriculture. Those values, however, are dispersed throughout many different areas of the world.

1. Introduction

The free exchange of international germplasm and genetic resources in agriculture has been the operative procedure for all but the last 100 years of world history. Crops developed in one area have quickly spread along trade routes to new areas where they were further bred and developed based on the local climates. The most dramatic of such exchanges in recent history was the sharing of genetic resources from the Americas to Eurasia and Africa from the 15th century forward. The benefits that the world's population has received from improved nutrition and flavor in their diets from this exchange are incalculable. Such international exchanges of germplasm rarely if ever compensated anyone as the owner of the genetic resource. The research involved in the generation of economically useful germplasm has often evolved over such a large number of years that the current owners might be only vaguely related to the developers. Efforts to assert ownership over genetic resources have, until recently, rarely been successful.

There are a few cases of countries trying to maintain their genetic resources as trade secrets. One of the more dramatic examples comes from Latin America. As the demand for rubber increased in the last half of the 19th century, Brazil tried to maintain a monopoly on its production by banning any export of rubber trees or seeds. This monopoly was broken in 1876 when an Englishman, Henry Wickham, bribed a customs official into letting him leave the country with a large number of seeds. It took a few decades to perfect the process of growing rubber trees in British colonies such as Ceylon and Malaysia, but by the 1920s competition from Southeast Asia had decimated the Brazilian rubber industry.

The international exchange of germplasm has created a situation in which many crops are produced primarily in areas distant from where they were first developed. In addition in most areas where major crops are grown, the genetic diversity available in the area is quite poor. Most of the genetic diversity of major field crops in the world is concentrated in a number of small areas away from where most of a crop is grown. For example, the areas of major diversity in wheat varieties and relatives, areas such as mountainous areas of Turkey, Syria, and Ethiopia, are far from the major wheat producing areas of the world in North America and Australia. Rice is the exception, in that it is primarily an Asian crop, which is also the area of its domestication and primary diversity. On the other hand, most Asian rice is grown in irrigated areas far from its area of genetic diversity.

Thus, if those in an area of genetic diversity can claim ownership, then genetic diversity is very unequally distributed. That distribution, however, is skewed toward some very poor areas of the world, such as the mountains of Ethiopia. This distribution of genetic resources can also have important implications on strategies to manage genetic resources.

Changes in global markets in the last twenty years have dramatically changed both the ownership and potential values associated with genetic diversity in agriculture. New ownership rules have increased economic values, while at the same time potentially disenfranchising former owners of genetic diversity. Ownership matters because it creates value, so this work starts with considering different ownership arrangements and then proceeds to the valuation questions. The reader will notice that in fact the issues are not as neatly separable, since different types of ownership have important implications for the value of genetic diversity and germplasm.

2. Conservation of Genetic Diversity in Agriculture

There are two types of conservation of genetic resources in agriculture:

- *in-situ:* in its place of origin, farmer's field, or nature reserves
- *ex-situ:* in seed banks or botanic gardens.

2.1 *In-situ* Conservation

Over time, valuable germplasm for agricultural production has been developed by experimentation by farmers. The typical process has farmers conserving the best seeds from the previous year’s harvest and replanting the next year. Occasionally a farmer might add in some seeds from a neighbor or a distant village. In this process, farmers are both improving the local seed variety and conserving a genetic resource that has desirable traits for the local microclimate. Such a process, of farmer selection and maintenance of a seed variety, represents a type of *in-situ* conservation of a genetic resource. Anywhere that seeds are regularly saved, rather than purchased every year, a certain amount of *in-situ* conservation takes place. However, the major sources of genetic diversity in *in-situ* collections tend to be close to a crops origin or where weedy relatives can be found. In some cases, important *in-situ* collections remain in the wild and can be preserved by limiting human encroachment.

The major values in farmer-maintained *in-situ* collections are in the hands of relatively few farmers, most of whom do the conservation not for the good of the world’s crops, but for their own crop production. As farmers integrate into the world economy and purchase more of their seeds, fewer farmers can be expected to continue to maintain *in-situ* seed collections. Thus, many *in-situ* collections of agriculturally useful genetic resources face a risk from encroachment and farmer integration in the world economy.

Many have worried that newly purchased varieties will replace old genetically diverse varieties, leaving the world without enough genetic diversity in agriculture. Some solace for farmer maintenance of *in-situ* collections, however, can be taken from the frequent partial adoption of new varieties. To the great consternation of agronomists throughout the world, one usually finds that 10-20 percent of fields are not planted with a new variety even when the new variety is superior to the old. This means that some genetic mixing will inevitably occur and much of the old genetic resource is conserved.

2.2 *Ex-situ* conservation

In the last 30 years, there has been a great expansion of the size and number of gene banks for conserving genetic resources in agriculture away from their site of origin, or *ex-situ*. *Ex-situ* germplasm collections are maintained by both the public and private sector. While most national agricultural research systems and a number of large seed companies maintain *ex-situ* genetic resource collections, the major seed banks are maintained by the CGIAR system. The CGIAR system has most of the countries of the world as members and has research stations throughout the developing world. The CGIAR system does crop research in the public domain and maintains the world's major international germplasm collections. The CGIAR system has the world's best-documented collection of germplasm: plant varieties as well as wild and weedy relatives.

The system was founded on the principle of improving crop research for poor farmers in developing countries. They conduct an open system with all researchers, public or private, having access to germplasm for legitimate research purposes. In addition, their crop varieties are released without any sort of intellectual property rights attached. Recent changes in intellectual property rights laws have increased private sector interest in the CGIAR systems germplasm collections. While in some cases this has called into question the expense of public monies, *ex-situ* collections as public genetic resources are likely to continue to be important for the foreseeable future.

2.3 Optimal Mix of *in-situ* and *ex-situ* Conservation

There is a lively debate in the literature on the optimal allocation of efforts in *in-situ* and *ex-situ* conservation of genetic diversity in agriculture. Some of the issue revolves around property rights and methods to allocate them in order to give the right incentives for the optimal levels of diversity to be conserved. While *ex-situ* conservation has easily defined property rights, it suffers from being expensive and the potential for being captured by individual corporations or countries. *In-situ* conservation suffers from ill-defined property rights that induce under investment, but are relatively less expensive. Note that because it is based on geography, *in-situ* conservation is not easily captured by corporations, but the benefits can be captured by individual countries.

Overall, both *in-situ* and *ex-situ* conservation of genetic resources in agriculture is needed. Thus, some of both types of conservation will need to be maintained by both public and private entities. The optimal levels of investment in each type has yet to be determined and will likely be determined by the current debate on property rights in agricultural genetic diversity.

3. Ownership Issues

Although the location of genetic diversity is determined by geography, the international rules of ownership are derived, not from geography, but instead primarily from rules developed in industrialized countries. These rules are primarily designed to protect the investments made by individuals and companies in research and breeding of new plant varieties. This section describes those rules and regulations.

3.1 Rules, Conventions, and Regulations

For most of history, breeding of plants has proceeded with little intellectual property protection. In many cases breeding lines were kept as trade secrets, but before the advent of hybrid varieties in beginning of this century, such trade secrets were readily copied. Recent rules to protect the rights of inventors and breeders in the form of patents are intended to spur the level of research being done and to provide for the revelation of privately held information. In exchange for publicly describing a new variety, patents provide some form of exclusive rights to the owner of the patent. The returns from this monopoly over a plant variety are intended to compensate for the cost of research. The remaining parts of this section describe the international rules for intellectual property rights on plant genetic material.

3.1.1 Plant Variety Protection Acts

In 1930 the United States government passed the Plant Patenting act, which was the first attempt to provide plant breeders with intellectual property rights over plants that were asexually propagated. Over the course of the ensuing years, a number of other developed countries promulgated similar legislation. In the US, the Plant Variety Protection of 1970 strengthened the original plant patenting act legislation, by protecting the rights of plant breeders. This led to an increase in the numbers of applications for plant patents from companies and also an increase in the numbers of patents given to universities and other public sector institutions.

The rights conferred by these acts are similar to those of a standard utility patent with some exceptions including a lower ability to preclude use and propagation of the plant by either farmers or for research purposes. Plant variety protection patents protect varieties that can be shown to be "new", "uniform", and "stable". Unlike utility patents, plant variety protection act patents have lower standards of novelty and utility than utility patents. This usually makes them both easier and less expensive to obtain. The trade-off is that the levels of protection provided against imitation and use by others are lower. Typically, time limits on plant varieties are similar in length to utility patents, at around 20 years. That is in exchange for describing the new variety, and the owner is granted limited monopoly rights to the sale of the product.

3.1.2 UPOV

In 1961, the Union for the Protection of New Varieties of Plants (UPOV) was established with signatories from 28 countries. The countries involved were primarily from industrialized countries, though a small number of developing countries, such as

Argentina, South Africa, and Uruguay were also early signatories. Currently a total of 46 countries have signed on to the agreement, of whom twelve are developing countries.

UPOV sought to harmonize the international rules on plant property rights and allow breeders to claim plant breeders rights over plant varieties. The most recent amendments to UPOV were in the early 1990s, which gave more clearly defined rights to plants produced through genetic manipulations. UPOV has from the outset been primarily an organization of the developed world and has been criticized for not paying enough attention to the rights of farmers to have access to plant breeders rights. In particular, while the convention protects the rights of plant breeders to use varieties for research, it allows, but does not guarantee, the rights of farmers to reuse seeds.

3.1.3 Utility Patents of Plants

As opposed to plant breeders rights, intellectual property rights or utility patents have been much less common for plants and plant varieties. A utility patent, which is often thought of as the standard patent, has both higher requirements for novelty and higher levels of protection than a plant patent under the plant variety protection act. In particular, a utility patent requires that the inventor demonstrate the usefulness of the invention and that it is not part of common knowledge. In exchange for divulging the method used to generate the invention, the inventor receives exclusive rights to sell the invention for a specific period of time. In terms of plant resources, this exclusive right allows the inventor to preclude farmers or other researchers from propagating the plant, giving the inventor a strong monopoly position in the sale of the good.

Currently, the United States is the only major developed country that allows utility patents on life forms. In 1980, the US Supreme Court decided, in the Diamond *vs.* Chakrabarty case, that it was allowed to patent life forms, in this case a bacteria. This ushered in the era of biotechnology patenting in the US. From that point on, the US patent office has slowly developed rules on patenting life forms, including plants, as part of the standard utility patent laws. One should note that these changes for the most part represent changes in interpretation of the law as opposed to new legislation on patenting life forms.

Due to the novelty requirements in patent law, in order to patent a plant under the utility patent law, one must in most cases show a non-trivial genetic modification. However, a number of plants and seeds have been patented seemingly without major modifications of existing crops currently grown in the world. For example, a patent was issued on a variety of bean very similar to one grown in Mexico, suggesting that novelty requirements were not especially high. Current litigation of patents of a number of examples of this type should clarify the requirements for novelty in the future.

3.1.4 International Trade Issues

International issues in intellectual property rights for living organisms in general, and plants in particular, have become increasingly important. The *World Intellectual Property Organization, WIPO,* was created in 1974 to help provide a mechanism for harmonizing intellectual property rights in different countries. Its main function is to provide a clearing-house for information on national intellectual property rights laws, a number of which are directly related to genetic material.

The *Convention on Biodiversity, CBD,* signed in 1992, was developed as a way to address country ownership of genetic resources, including germplasm, in a way that promoted conservation. Farmers' rights were considered in the negotiation of the *CBD*, but most of the rules established ran counter to farmers' rights. The convention gives countries the rights to their genetic resources, but denies them any claim as to the origin of genetic materials already transferred to other countries.

In addition, in the last round of international trade talks, the Uruguay Round of 1995, agreements were made on *Trade Related Aspects of Intellectual Property Rights, TRIPs,* that included articles on genetic resources. In particular Article 27, 3(b) requires countries to allow plant variety protection by patents or to have their own *sui generis* system. *Sui generis* implies that countries must design their own unique plant protection system. The key feature of the Article is that all countries must have some effective system to protect plant intellectual property rights. The *TRIPs* agreement also provides more universal recognition of plant breeders rights and sets the minimum patent duration at 20 years.

Despite the international agreements, industrialized countries are, for the most part, the only ones with the appropriate laws and enforcement. Most developing countries have not in fact made the necessary changes to their laws to conform to the agreements. Since most developing countries are not major producers of new plant varieties, they have little to gain from conforming to these laws. Their main benefit is to gain the good will of developed countries or to reduce the threats of sanctions. Many developing countries have made the effort to look like they are making progress towards legislation, without making much progress. Since these issues are still relatively minor in the world of trade disputes, they may only be resolved slowly. The quickest route to resolution will probably come from finding a system that has some benefits for developing countries.

3.2 Farmer's Rights

Critics of the current intellectual property rights regime suggest that it (i) skews research away from the most socially useful types of research, (ii) it favors regions relatively poor in genetic resources (industrialized countries) over those rich in genetic resources, (iii) and it imposes a market system on previously free exchange of genetic resources. A farmers rights system has been put forth as a potential doctrine for managing international compensation and equity issues in genetic diversity.

The system of international farmers rights would have the following elements. Farmers rights are to be group rights assigned collectively to the owners and nurturers of genetic diversity, which would entitle them to some compensation from the users of genetic resources. These rights, however, do not imply standard monopoly rights because they are not assigned to individual people, plants, or varieties. Their implementation would require a direct levy on the users of genetic resources, which would then be returned to the owners of the farmers' rights. Due to how they are conceived as concerning all genetic traits in a plant or variety farmers' rights would not expire at any specific time limit. They are, in particular, seen as a way to increase incentives for *in-situ* conservation of genetic resources.

Among the potential problems with farmers' rights is that, while they are created in order to reduce inequities, they instead have the potential to create increasing inequities. While the major areas of genetic diversity are in poor countries, large numbers of poor countries are not owners of major genetic collections. For example, the country of Chad has little in the way of valuable genetic plant resource. But, as a user of genetic resources and a potential beneficiary of genetic improvements, such as drought tolerant sorghum, could be liable for relatively large payments to the owners of genetic diversity. Most farmers' rights proposals suggest that only developed countries would have to pay, but it is not clear what the income threshold might be or whether poor farmers in developed countries could be exempted. In general, as a method of correcting international income distribution inequalities, farmers' rights do not seem to provide any relief.

Aside from what is potentially a logistical nightmare in terms of figuring out how to assign rights, there are a number of other potential problems with this proposal. Since farmers' rights are collective rights, they are unlikely to spur much additional research or improve the incentives to conserve genetic resources. They maintain most of the collective action problem implicit in the old system of providing no intellectual property rights to farmers. The compensation that an individual farmer receives would be channelled through their government or an international entity. Since the typical government, even in developed countries, is more likely to spend money on urban than rural peoples, it would seem unlikely that a farmer could receive adequate compensation. Even a benevolent international agency could be expected to waste most of its funds on the bureaucracy involved in compensating the appropriate farmers.

A further problem with a farmers' rights proposal is that it is based on the idea of rights that would never expire. This creates a type of property rights in perpetuity. Current intellectual property rules place maximum time limits on the length of patents. Based on those rules, most of the genetic modifications in plants currently in existence would, if they had been patented, have come off patent already. This is perhaps the saving grace of patent law, that in the long-run the information becomes publicly available. Farmers' rights rules would take this away and would cause compensation to have to be paid indefinitely, potentially creating more distortion than already exists.

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Biographical Sketch

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