Plant biotechnologies :

What is common and what remains private ?

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Abstract:

The purpose of this paper is to analyze, in the field of agricultural biotechnology, how can the changes in research organization and in intellectual property right help us to build optimal research organization design and optimal intellectual property right regime in the future? Firstly we analyze why the genetic resource status has evolved from a common heritage of mankind to the status of private property or club good. Dealing with the perverse effects of this status change, I present the answers that are made by the international and national institutions. Finally, the actors themselves -public and private laboratories- have proposed alternatives that lead today to consider a new status for genetic resources and other research inputs: the definition and creation of common property goods.

Keywords

Intellectual property right, patent, biotechnology.

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Introduction

The incentives for innovation and its dissemination is at the heart of economic theory. What are the objectives of innovation and its dissemination? This is to accelerate economic growth and social welfare by improving the creativity and competitiveness. Public regulation of intellectual property rights may be necessary, with the creation of temporary monopolies[1] to both encourage innovation and maximize social welfare. In this context, economists (Gilbert and Shapiro, 1990, ...) propose to find and implement an optimal intellectual property right. I.e. to define the characteristics of intellectual property rights to achieve a social optimum[2.] This optimal intellectual property right is strategically chosen in each country on its own characteristics: the organization of economic sectors, R & D capabilities of public and private laboratories, level of effective demand, ... (Trommetter, 2010a).

Linked to this overview, the purpose of this paper is to analyze, in the field of agricultural biotechnology, how can the changes in research organization and in intellectual property right help us to build optimal research organization design and optimal intellectual property right regime in the future? Firstly we analyze why the genetic resource status has evolved from a common heritage of mankind to the status of private property or club good. Dealing with the perverse effects of this status change, I present the answers that are made by the international and national institutions. Finally, the actors themselves -public and private laboratories- have proposed alternatives that lead today to consider a new status for genetic resources and other research inputs: the definition and creation of common property goods.

1. History of plant breeding

The economic stakes in agricultural biotechnology cannot be understood without realizing a historical analysis. Indeed, the domestication of the species by hunter-gatherers dates back to Neolithic times. The improvement of plant varieties by farmers, on the basis of exchanges and "empirical" breeding, continued throughout the centuries and continues today in many parts of the world (Chauvet, 1986).

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[1] Intellectual property right on an innovation gives the holder the ability to define access and use. Intellectual property right is considered as a necessary evil to achieve innovation because without such intellectual property there is no innovation. It should nevertheless be careful not to confuse intellectual property rights and authorization to put on the market

[2] For a survey on the issues of intellectual property right, Langinieux and Moschini (2002).

During the 19th century, companies specializing in plant breeding have been created (eg Villmorin, France). But in Europe, their plant improvement activity remains marginal compared to the improvement activity of farmers and/or public research.

1.1. The end of World War II to 1980: a selection based on the status of pure public good

After the Second World War, there was a will in Europe and especially in France to be food self sufficiently. To do this, the National Institute of Agricultural Research (NIAR) is established in 1946. Its objectives are to select varieties of plants and animals to make France nutritionally self-sufficient.

At the end of the 50s, the main activity of seed companies is to sell new varieties produced by NIAR. These companies understand that there is a way to capture a greater share of the value added: they must develop their own new varieties. At that time, the plant breeding is based on conventional cross-breeding assisted by phenotypic markers. The organization of research in France and Europe is then based on the use of high genetic diversity, both from the genetic resource collections and improved plant varieties. Genetic resources are the common heritage of mankind.

At this stage of the organization of research and the development of a private seed sector, the difficulty for companies is that there is no protection of plant varieties. Innovations are easily imitated by competitors, except for hybrid seeds whose parental lines are kept secret. Some firms think to protect plant varieties by patent, but this tool is inadequate as in the substance -the process of creating the variety is not new- as in the form -the patent prevents the access to the genetic diversity of protected plant varieties without the permission of their owner (licenses)-. Plant breeders prefer then to promote the creation of the International Union for the Protection of New Varieties of Plants whose mission is to provide a tool for *sui generis* protection of new varieties. This tool must be compatible with the characteristics of the organization of plant breeding in Europe.

UPVP proposes the "plant variety protection system" PVP. This right is what economists call an optimal intellectual property right (Gilbert and Shapiro, 1990) and what lawyers call a *sui generis system.* In economics it is assumed that each innovation must lead to a particular intellectual property right by defining what is protected (or not) for how long and with what claims (scope). For lawyers, a *sui generis* right is a right that is specific to a particular type of innovation in a particular sector. The PVP is revised in 1978, PVP78. What are the characteristics of this right and what makes it optimal for the seed sector?

* First, PVP78 protects the plant variety innovation from all the manner of the copy. That is the minimum for the innovator. The concepts of imitation and dependence are limited in breadth.

* Second, PVP78 provides free access to the genetic diversity for the purpose of breeding. The research delay is considered as adequate between the first cross-breeding and the variety put on the market (8 years minimum) so that there is a positive return on investment for upstream innovator (incentive). There is an open access, free of charge and non-contractual to genetic resources for research and plant breeding. Genetic resources are then considered as a common heritage of mankind throughout the chain of research since the diversity of wild species until marketed plant varieties. So we are dealing with a pure public good for research, for which there can be no exclusion (access) or rivalry in use (use's right). Transaction costs to access genetic diversity are close to zero.

* Finally, PVP78 guarantees a right of farmers to replant their fields with their own seeds of protected varieties, which can be interpreted as a recognition of the earlier role of farmers in the conservation of genetic resources and plant breeding. The farmers' privilege can be interpreted as a "result sharing" between plant breeders and farmers. This result sharing may be associated with the use by professional breeders of materials made by "improver farmers" over the previous decades. The concept of a pure public good is not always appropriate to share the results with farmers. The State may restrict certain uses of varieties. For example, in France, legislation prohibits farmers to sell or exchange protected varieties. They are even "obliged" since 2004 to pay a "voluntary" contribution required to replant their fields with their own seeds[3] (law of June 30, 2004).

During this period, the scientific paradigm is to facilitate the access to genetic diversity which refers to the economic notions of public good and result sharing. It is naturally associated with the status of common heritage of mankind for genetic resources.

[3] The objective is to have a sufficient R&D budget in private companies. The French policy is based on two variables: the demand on the seed market by prohibiting trade and exchange; direct funding of research through the contribution.

1.2. From the 80s to 2000: the emergence of genetic engineering with its advantages and limitations

In 1974, Cohen and Boyer create the recombinant DNA technology. This innovation is a generic technology for any development of research in genetic engineering. A patent is granted on this technology. Then, in early 1980 the first patent on a living modified organism has been granted (a microorganism) and in 1986 the first field trials of genetically modified organism (GMO) has been made.

1.2.1. How to protect biotechnological innovations?

Innovations in the field of plant biotechnology are based on technological innovations, particularly mutagenesis and transgenesis. Technologies and gene sequences often simply identified are patented with different dissemination strategies (i.e. licensing) : for example, the Cohen Boyer patent on the technology of recombinant DNA brings in money more than hundreds millions of dollars because of multiple inexpensive licenses, while the company *Myriad Genetics* in human medicine has refused to license its tests screening for predisposition to breast and ovarian cancer, blocking the access to BRCA1 and BRCA2 gene sequences covered by the patent. These two radically different behaviors, in terms of dissemination of innovations, do not prevent patent offices to grant patents on many gene sequences. There is then a reconsideration of the status of genetic resource as common heritage of mankind in the biotechnology innovations and so a reconsideration of low transaction costs for access to the resources. Trommetter (2012) raises the question: Why do patent offices have granted patents on living organism and accepted so broad claims?

* First of all genes are chemical molecules. Either, but Henry et al. (2003) state: "In terms of the functioning of a living organism, it is above all information materials and contractors, the codes that control and induce biological activities essential, complex and diverse. "

* Second, the chemists usually patent chemical molecule with claims for all purposes arising from the use of this molecule, which for a artificially "created" molecule[4] is economically justified;

[4] Henry et al. (2003) point out that "the major patent offices, such as the USPTO (United States Patent and Trademark Office), EPO (European Patent Office) and their Japanese counterpart, deal a gene as they treat a molecule developed by chemical or pharmaceutical industry: it is a "composition of matter" or "compound material", or a patent on a "composition of matter" involves automatically all rights to all the applications it may one day be the support."

* The creation of incentives for private companies involved in genome sequencing networks. Because research-based sequencing technologies are long and expensive[5]. That argument is perhaps less easily justified economically and socially. It relies mainly on a political decision.

Despite these arguments rather adverse to the patentability of living, the patenting of life associated with a simplistic representation of the functioning of living is considered as "acceptable". At that time, the scientific paradigm is: a genetic sequence codes for a single function.

We see that in the debate on the patenting of life we highlight that the fact to accept (or not) to sell a license as an easy (or not) access and dissemination of innovations to competitors. So we specify the impact on transaction costs. Other factors associated with license agreements could be important. In particular the clauses of the contracts that stipulate the uses rights for the licensee. This is strategic in plant biotechnology. Thus, in a dispute between Monsanto, DuPont, the Court ruled in favor of Monsanto by declaring that "DuPont violated the agreement on the licensing of the company by combining the *Roundup Ready* tolerance gene of Monsanto with a DuPont's gene having the same effect. " This means that beyond royalties, user's use rights define the minimum distance between two innovations to that there is no dependence (Trommetter and Tropeano, 2009).

1.2.2. What are the consequences? constraints or facilitators for future research

What are the implications of intellectual property right strategies and licensing on the organization of research in agricultural biotechnology?

To block future research? In the mid-90s, the evolution of scientific results lead to a new paradigm which contradicts the previous one. The scientific paradigm associated with genetic sequences is more complex than scientists had expected: a gene may be involved in several functions and one function may be the result of an interaction between several genes. Along with this discovery, intellectual property policy in the field of agricultural biotechnology remains strong, which led to a proliferation of intellectual property rights, some of which may be overlapping with very broad claims granted. This led to what Heller and Eisenberg (1998) called the tragedy of the anti-commons and what Shapiro called the challenge of patent thickets management. In both approaches, it was shown that transaction costs have increased

[5] At that time, the sequencing activity is manual. In European programs, laboratories are funded of about 2 ECU (€ 2) the base pair.

significantly and could even become prohibitive and potentially blocking for research. This is especially true in case of license refusal, prohibitive royalties or too restrictive contractual clauses. These "patent thickets" are sources of uncertainty, the patent owner may refuse to grant a license, and they make users bear high transaction costs.

The results of Ménière et al. (2008) are a little bit different : the multiple and overlapping rights do not automatically lead to research blockages. It appears more appropriate to speak of research delays, research reorientation or delay to get around previous patents. These delays have in any case a negative impact on research, both in terms of timing in the patent race for innovation as at the level of research costs (Meniere et al., 2008).

To block access to research inputs? With the proliferation of intellectual property rights on innovations in biotechnology, it is difficult to negotiate the terms of access and use in the license agreements, which have collateral effects on the conditions of access to inputs of research: genetic resources; improved genetic resources; databases; collections of mutants; ... Because the constraints of access and use on innovations have hardened to the holders of inputs for research, they decided to tighten the conditions for access and use their inputs. Unreasonable conditions are observed without relation to the total investment expenditures : tangible, intangible and working time. We refer here to an example presented by Teyssendier and Trommetter (2004), it focuses on the conditions for access to a mutant collection: the case of Garlic Syngenta. This example may seem relatively old but is still relevant as genetic research are becoming more complex in that they use more and more interdependent inputs (see section 3).

" Syngenta linked the supply of insertion mutants of *A. thaliana* (GARLIC collection) to the signing of an MTA to be signed stipulating the following:

- The demander researcher is prohibited from working in collaboration with teams of other organizations or companies without the agreement of Syngenta.
- The demander is obliged to transmit, free of cost and at least once a year, to Syngenta all the results obtained by means of the mutant without this company being obliged to specify how it will use them.
- The demander must submit all drafts of publications to Syngenta, which may suppress all the confidential information they contain.

- Syngenta may patent any result that the demander does not wish to protect on its own account.

The demander must consent to a right of first refusal to Syngenta for any commercial use of the results (in other words a priority for use under licence). This thus prevents negotiation with any other company. The demander will be obliged to negotiate a licence for the benefit of Syngenta subsequently, an exclusive licence if Syngenta so demands."

To less cooperation in the upstream phases of research (less knowledge sharing)? There may be situations in which there is no blockage to access to inputs, but a refusal to participate to the creation of upstream common inputs. Thus, Maurer (2006) gives the example of *"mutation database initiative"*. There is a will to centralize data on human gene mutations that belong at least one hundred biologists. They are looking at : how to reorganize databases and collections and how to finance the reorganization? This initiative failed because the smaller laboratories refuse to participate. They are afraid to see their work appropriated by large groups without being compensated for their work (equitable benefit sharing). The issue of protection and dissemination of databases and especially the data they contain is at the heart of this point (see examples in Box 1).

Is free paid access to research inputs always negative or can it be a source of research progress? In the case of databases, Incyte and Celera warrant the condition to pay for access through non-exclusive licenses as a contribution of the subscribers to research costs so Incyte and Celera can more rapidly develop their database and thus provide even better service to their subscribers. Given the increasing number of databases, one can envisage the creation of database pool situation also encountered during the creation of standard and where the royalties are based on the number of patents held in the standard (Lévêque F. and Ménière, 2009). Create a database pool requires negotiating the distribution of rights for actors, the rights are based on the level of participation of each actor in the pool. In all of these examples, the idea is that the creation of a database is expensive and that purchasers (licensees) pay a fee based on the costs of research and not on the value of innovation. Compared to the model Trommetter and Tropeano, 2009, Celera / Incyte model is closed to the cooperation behavior with cost sharing. Nevertheless, there differentiation by the ability to pay the entry cost is not insignificant.

Box 1: Conditions of access to databases

Walsh et al. (2003) explain: "*For example, with substantial public, private and foundation support, public and quasi public databases have been created, making genomic information widely available. The NIH has also negotiated with owners of foundational technologies, such as stem cells or genetically altered mice, to ease publicly funded researcher's access to these important research tools. Scientific journals have pushed authors to deposit sequences in publicly available databases as a condition of publication.* " These are individual initiatives for the realization of a collective good. How is it possible institutionally and politically to go beyond the financial incentives? Particularly for the equipment financed by public funds.

Paid open access with non-binding uses: Research in bioinformatics requires access to a large number of databases. This access has become a major issue for rapid achievement of innovations, particularly in the field of genetic disorders. In the context of microbial genomes, two databases developed by Proteome, the YPD (Yeast Proteome Database), which is a reference source for the sequencing of *Saccharomyces cerevisiae*, and the WPD (Worm Proteome Database), for the sequencing of *Caenorhabditis elegans*, were recently bought back by Incyte Pharmaceuticals. In exchange for access to these two bases, which was initially free, Incyte Pharmaceuticals demanded payment of a licence fee (Aime-Sempe, 2002). This induced additional research costs which could become prohibitive if all database owners decided to follow the practice of Incyte Pharmaceuticals.

Access charges associated with differential differentiation of the constraints on use: In the early 2000s, Celera Genomics provides access to its database at differentiated prices. Thus, if a demander is a private company, the price of access to the database is US$ 15 million per year without other consideration, the payment is *ex-ante* to the realization of an innovation that could be make by the company, which can be considered as a paid open access. By cons, if the demander is a public laboratory, the access price is only $ 10 000 per year but the laboratory undertakes, if he achieves an innovation to commercial utility, to pay royalties to Celera Genomics (Lima 2001), so to pay counterparties *ex-post* to innovation;

2. Answers at several levels

Faced with these threats for research in biotechnology and thus for the realization of innovation, answers are given at several levels: international conventions and national and regional legislations on intellectual property right.

2.1. At the international level: the end of the common heritage of humanity

The Convention on Biological Diversity, signed in 1992, formalizes the end of the status of common heritage of mankind for genetic resources, there is a national sovereignty of states to manage their genetic resources. This means that it is the States which must define the institutions or individuals that are responsible for the management and exploitation of genetic resources. You enter in the field of bilateral contractual relationship in which the bargaining power will have a strategic role. Given the difficulty of countries to implement the conditions of access and benefit-sharing, the CBD helps to create a protocol on the access and benefit sharing. This protocol is presented in Nagoya in 2010. The objective of this protocol is to harmonize, at most, the clause of the access contracts to limit transaction costs and, for developing countries, reduce the risk of abuse of multinational companies.

The model of the CBD with its protocol tends to converge to the model of the FAO -Treaty on Plant Genetic Resources for Food and Agriculture-. The treaty provides that the access to genetic resource collections is based on a multilateral system for exchange. This system assumes that each country has a list of available samples per species[6]. There is a transfer of jurisdiction over the accessions which are put in the multilateral system. Access is free for public laboratories and companies of each country which signed the commitment. Access to samples of the multilateral system is based on an harmonized contract (the Standard Material Transfer Agreement). Genetic resources are club goods, to which access is controlled by a sole contract. The aim is to reduce the risk of private appropriation of resources without compensation from the downstream innovator, while minimizing transaction costs. This facilitated access to genetic resources raises the question of access to intermediate material, for example, the parental lines of hybrid varieties. The lack of access to parental lines introduced delays in the identification of genetic combinations leading to the hybrid, so additional costs.

[6] The number of species covered by the treaty is limited. The list includes 64 species and is attached at the end of a treaty (annex1).

What are the characteristics of these contracts-SMTA-: Open access is not synonymous to free access, so access to genetic resources collections can be paid (shipping, access rights, ...); The actual use for commercial purposes of the genetic resources leads to voluntary or compulsory compensation depending on the level of private appropriation of genetic resources contained in innovation and / or the innovation itself. The level of compensation depends on the level of private appropriation of the resource is itself a function of intellectual property rights on innovation and the dissemination of innovations (product sold, licensing). These compensations are voluntary or compulsory and are paid into an international fund whose use is related to the conservation of plant genetic resources and development of innovations to the south.

2.2. In terms of redefining and implementing intellectual property rights and licenses

Faced with scientific and technical developments, patents are increasingly mobilized to protect biotechnological innovations, the PVP must evolve to not disappear. With the evolution of genetic engineering and transgenesis, there is a risk that the improved material by breeders (agronomic quality) will be appropriated by firms specializing in GM (resistance to a herbicide, pesticide, ...). To limit this risk, UPVP reviews the PVP in 1991 and defines and implements the concept of "essential derivation" which aims to extend the notion of imitation (minimum genetic distance between varieties). UPVP takes the opportunity to review the farmers right which becomes optional so there is a will to further limit the uses right for a farmer[7].

Meanwhile, the fact to protect the seeds by PVP or patent, according to the technology - traditional cross breeding or by inserting genes- led the EU to provide flexibility in its directive on biotechnological inventions 98/44: the possibility to resort to compulsory cross-licensing in plant biotechnology to resolve disputes between private actors[8]. These licenses guarantee the protection of innovation with a "free paid access" to genetic resources. Easy access to genetic diversity is no longer automatic (contract) or free (cost of access; royalties), but it remains a priority in Europe (Trommetter, 2010b).

[7] The objective is the research of R&D budget esteeming that farmers were well compensated over the years and can use traditional local seeds if they don't want to have to pay. This is not the case in France but this is not the subject of this paper.

[8] Directive 98/44 Chapter III on compulsory cross licensing for dependence.

The transposition of the biotech directive into French law in December 2004 provides another flexibility by adding a section to limit the scope of patent protection (613 art.L 5-3)[9]. This article aims to ensure access to genetic diversity including GM varieties that incorporate a (several) patent(s) on gene(s), a patent on a gene in a GMO is no longer extended to the plant as a whole. There is free access to the genetic diversity of the GMO, unless the patented gene. The use of this genetic diversity in free access is facilitated by biotechnology innovations such as selection assisted by molecular marker which give the opportunity not to select the cross-breeding results in which the patented gene is present. Thus, access to genetic diversity becomes automatic, open and free to research but with other constraints in particular on the access to seed markets in countries that simply implement the compulsory cross license between patent and PVP, for example. The aim of France is to protect the features of the seed sector with more than 60 companies in the sector often with national or local markets.

Other countries have specific laws which are interesting to analyze for the seed protection or access to genetic resources:

* Brazil has implemented a national legislation which is intermediate between PVP78 and PVP91. Brazil implements the concept of essential derivation while protecting farmers' privilege. They built a law according to their national characteristics both in research organization and demand solvency (Trommetter, 2010a). Brazil has built a property right which can be described as "optimal". This seed's law is more restrictive than the PVP78 for breeders while guarantying some rights to farmers. Note that Brazil is a member of the UPVP Convention 78, more protection can be done but not less. This is probably why Brazil has not yet adhered to the UPVP Convention 91, more burdensome for farmers.

* India accuses Monsanto of having "stolen" traditional local seed to develop a genetically modified variety known as "Bt eggplant." Indian law states that using plant material without permission for commercial use is considered as an act of biopiracy. While the eggplant is in Appendix 1 of the FAO Treaty, if the traditional local seeds are not put in the multilateral

[9] "Art. L. 613-2-2. - Subject to the provisions of Articles L. 613-2-1 and L. 611-18, the protection conferred by a patent on a product containing genetic information or consisting of genetic information shall extend to all material in which the product is incorporated and in which genetic information is contained and performs the function indicated.

Art. L. 613-2-3. - The protection conferred by a patent on a biological material possessing, due to the invention, shall extend to any biological material derived from that biological material through propagation or multiplication and possessing those same characteristics.

Art. L. 613-5-3. - The rights conferred by Articles L. 613-2-2 and L. 613-2-3 do not extend to acts performed in order to create or discover and develop other varieties. "

system of exchange by India, India can force the use of these particular genetic resources by national regulations.

Optimal intellectual property is not unique, it depends on the characteristics of countries (Trommetter 2010a) Brazil and India defend their farmers and the uses that can be made of traditional local seeds face to the risk of private appropriation. France defends its seed sector which has some particularities, for example with niche markets.

At the national level, patent offices are reviewing their strategies to accept or reject patents on living organisms. Thus, the protection of genetic sequences in the early 2000 is only accepted with a function that is experimentally proven, even if the claims are granted wide. In the mid-2000s, the perimeter of the function found has gradually narrowed. The risk of dependence decreases for seed companies. Patent offices are reviewing their strategies for dealing with molecular marker-assisted selection. Two limits can be presented for the marker-assisted selection:

• The ability to quickly copy a specific characteristic developed by traditional cross-breeding techniques;

• The ability to patent a plant or an animal variety selected by conventional breeding and assisted by molecular markers (eg EP 1 069 819 of broccoli).

In the first case, there is risk of a rapid appropriation of an upstream costly work by competitors, the concept of essential derivation can not be applied to this type of situation. In the second case, the patentability of plants and animals is traditionally contested in Europe, an appeal has been filed with the BoA of the European Patent Office. The decision of the BoA is to refuse the patent on broccoli, considering that the variety is produced by an "essentially biological process".

Faced to the risk of blockages and delays in research, national and regional policies have sought to limit the adverse effects of past patents while maximizing intellectual property to encourage future research. The case of marker-assisted selection is an example quite interesting because to date the only question that have not been solved: the issue of copies of specific characters. UPVP is working on a reform of the PVP, but it is not necessary if the implementation of a new tool (for example an extension of the concept of essential derivation) is more expensive than the result that it would achieve (license and benefit sharing).

3. Organization of research and creation of new "public goods"?

Faced with different constraints to access and institutional solutions that were presented, initiatives are being developed by the actors of the research themselves. These initiatives aim to reduce the harmful effects of the implementation mechanisms of intellectual property in biotechnology. These initiatives are linked: first a collective management of intellectual property today to limit the adverse effects of previous patents; second, a collective management of research which aims to collectively manage the pre- competitive research and start a competition (patent race) only in the product development phase.

3.1. Collective management of intellectual property

As recalled by Trommetter (2012): "The collective management of intellectual property must comply with rules issued by the courts in charge of the implementation of anti-trust regulations (for example, the Competition Council in France). The collective management should lead to improved social welfare, especially of consumer surplus. So in the absence of a situation of "abuse of dominant position", the research actors may consider the creation of a club to manage their patents, each remaining individually owner of its patents. " These clubs are designed to manage access and usage to a collective patent's portfolio:

* To identify complementarities to build innovations based on technology clusters (modular technologies identified "ex-post". It is therefore to provide a pool of patents with a single license in order to reduce transaction costs and avoid prohibitive royalty rates;

* To identify complementarities with other patent portfolios and facilitate access to licenses for these patents further;

* To participate in a club increases the bargaining power of each actor.

At the empirical level, PIPRA[10] in the United States in the field of plant biotechnology is a good example. Graf et al. (2001) explain that the implementation of a *clearing house mechanism* for managing the public patents is:

"* On the limitation of risks of patent thickets and to search and offer patent pool licenses attractive and / or make innovations in the public sector (for plant varieties orphaned towards developing countries);

[10] PIPRA-Public Intellectual Property Resources for Agriculture-, Atkinson et al., 2003.

* On a bargaining power more important to have access to patent licenses held by large multinational biotechnology. "

Collective management of intellectual property is put in place to limit the adverse effects of existing patents and to promote the use of patent portfolios of public research institutes. One consequence is to provide patent pools, thus reducing transaction costs and the level of royalties for the licensee with a sole contact (SMTA).

3.2. Collective management research: towards more coordination

To avoid the risk of being blocked by patents, research institutions both public and private, offer an alternative to the establishment of collective management of intellectual property: the creation of a new organizational design of research based on new collective and cooperative relations in the pre-competitive phases of research. Two approaches are possible: the result sharing and the creation of clubs, and the creation of public goods or common property goods. The difference between the two is a matter of definition of access rights, use rights and conditions of cost and benefit sharing.

3.2.1. The results of the research: joint property or public property?

The objective is to define the operating rules of research consortia so that they are cost effective and they do not fall within the scope of the rules of competition law: privileged access to information to certain members of the network; delay in the dissemination of certain information on the research results within the network. At the theoretical level there are papers on *"joint patents"* which are more numerous (Hagedoorn, 2003), but also the work of Cohendet et al. (2006) who see patents as an institutional tool of coordination in addition to being a mere tool of incentives. Bitter (2004) also stresses the need to share intellectual property when there is a real contribution of each partner. They are equitably share the costs but also the results.

In this framework on sharing intellectual property, the case Genoplante is instructive (Henry Trommetter and Tubiana, 2003): "In the contract Génoplante (French research consortium between public laboratories and private companies), the most fundamental patents will be filed by research institutes, while further downstream patents will be filed by private companies. The patent is managed by one of the actors in the consortium, the licenses can then be sold to other companies or laboratories more. The royalties from these licenses will be distributed among the various actors in the consortium according to their effective participation in the project. The participation of each player is measured from a "lab research book" held in each laboratory (time spent on the project, origin of the biological material used, techniques, ...). "

Other types of organization of joint research exist. They are not intended to lead to the collective intellectual property but rather the creation of club's property or public goods:

* The dynamic management of maize population program in the 80s and 90s in France. The principal objective is to reintroduce genetic diversity in the parental lines of commercial varieties. Participation in this research group is based on an egalitarian approach in cost-sharing program with possible opportunities to entry by paying the same amount as the previous participants (Trommetter, 2000). There is clearly a logic of creation of club goods.

* The consortium of structural genomics is to accelerate the production of new protein structures resulting from crosses of different partial gene sequences found in public databases (Williamson 2000). As part of the consortium on *Single Nucleotide Polymophism (The SNP Consortium*, TSC) over 300 000 human SNPs are put into the public domain (Williamson 2000)[11] This research is funded from private funds and are carried out by public and private research institutes. The issue is through these public data to discover more quickly genes of interest for the development of drugs (patentable innovations) by combining different databases without having to worry about whether or not a holder of intellectual property rights on the SNP used does exist (leave open access to sequences for all functions). It is clearly an approach to create public goods financed by private funds.

Hence, within consortiums and networked research activities, the definition of rules is a prerequisite for each research project. As Cassier and Foray (1999) show, an absence of rules at the outset automatically leads to opportunistic behaviours and to the end of research networks. The introduction of rules is therefore necessary to limit moral hazard situations, since the partners' actions cannot all be observed. There is a twofold uncertainty on the real activity of genetic evaluation and on the dissemination of information to the members of the

[11] The members of this consortium are: Wellcome Trust; APBiotech, AstraZeneca PLC, Aventis, Bayer AG, Bristol-Meyers Squibb Company, F. Hoffmann-LaRoche, Glaxo Wellcome PLC, IBM, Motorola Novartis, Pfizer, Searle, SmithKline Beecham PLC. The work funded by the consortium are carried out by four research institutes: Stanford Human Genome Center, Washington University, Wellcome Trust's Sanger Center and Whitehead Institute. The financial participation of each member is US$ 3 million; new members of the consortium shall pay such amount as entry fee, the Wellcome Trust has provided $ 14 million (Williamson, 2000).

network. The rules on the conditions of participation and even exclusion from the consortium are therefore central. If there is a sharing of costs and results, the approach has two steps: participate or not in common research (choice between participating or not), then set the rules of sharing and the levels of each partner's research efforts. We are not in an open organization where improvement is cumulative and shared with the copyleft license, we are in a cooperative vision and creation of club goods.

3.2.2. Coordination and interaction in research: the creation of common good

In biotechnology, research is increasingly complex and costly with the development of new technologies: genomics, proteomics, transcriptomics, ...). This led to a concentration in agricultural biotechnology. Wright and Pardley (2006) explain that this concentration is accompanied by the setting in the public domain of large amounts of genetic data.[12] In addition, new resources related to genomics are produced in abundance by Génoplante programs, ANR and European research teams combining public and private: genes inserted into bacterial vectors (BAC) or yeast (YAC), molecular databases (expressed sequence tags, cDNA, partial sequences), collections of mutants ... They are managed directly by the research teams or collectively through common platforms (French and European consortia ...) whose are commissioned to distribute them. Limited during the last decade to a few "model species", and the major crops, these resources explode with new sequencing technologies, cost reduction and involvement of international projects that lead to exponential growth of genomic resources and their extension to any cultivated or wild plants. The living is complex and we see that there is a will to have an increasing control on living organisms both at the technical level and at the intellectual property level. This is especially true for Gibson (2010), when he refers to the more recent work on synthetic biology and joint intellectual property rights. How can we manage this situation which may appear paradoxical?

Innovation depends increasingly on the coordination between various actors with different objectives and uses. In this context, the definition of collective or common rights has undoubtedly bright future. The work of Elinor Ostrom (Nobel Prize in Economics in 2009 and unhappy deceased in 2012) has to be mobilize and develop. Rolland and Kuntz (2011) recall: "Often the proteins do not exist as isolated entities but form complexes and interact transiently

[12] With the genetic association or genomic selection, researchers are seeking changes in characters and especially the regions of genome that have an effect on the variation of characters. Researchers therefore need easy access to large amounts of data but also software and platforms ...

with other proteins or metabolites. Databases on structural interactions or functional relationships between proteins are available. "

Thus, if we take the example of research on maize improvement, a paradigm shift is underway in maize breeding. Scientific breakthroughs are needed to take advantage of emerging technologies (eg. genetics association and / or genomic selection) and for better use of genetically agronomic potential of maize. They must develop tools, methods and plant materials for mapping and association studies on ecophysiological performance under abiotic effects.

This is to generate a new generation of innovative molecular toolkits that help in the creation of improved maize varieties. This is especially important as genetic resources are both "specific characters" and "genetic diversity as such," it is our insurance policy in an uncertain world where change is the norm. To block the access to genetic diversity is inconsistent with the notion of maintaining an ecological potential as advocated by ecologists. This raises two questions for the future: What is the optimal size of the private perimeter of the public research and what is the optimal size of the public perimeter of the private research? In this context, answering questions on intellectual property strategy and the definition of access and uses rights, and the implementation of rules for cost and benefit sharing are essential.

Is exceeded then the question of the creation of club goods or public goods to move towards the creation of common property goods within the meaning of Elinor Ostrom, which are based on coordination of actors in interaction and associated public regulations.

Conclusions and outlook

In this paper we have identified the reasons that explain the changes of status of genetic resources and inputs of research by the mode of protection of an innovation. We have seen that the private appropriation of innovations and genetic resources as they are, has had an impact on access to genetic resources and the inputs of research more generally, and led to the disappearance the concept of common heritage of mankind in favor of the status of private property and club goods.

We have seen that this has had negative consequences for research and that need answers to both international and national level, research actors themselves propose alternatives with the collective management of intellectual property and collective management of research to create club goods or public goods.

Today, the stakes linked to the coordination between the actors are increasing because the complexity of the research is growing (genetic association and genomic selection). These new models of research are mobilizing various disciplines -genotyping, phenotyping, biometrics, ...- which involve being able to access and create multiple inputs-access to collections and parental breeding lines (maize), access and creation to collections of mutants, access and creation of platforms, access and creation of databases ... To get to coordinate all of these players while limiting the risk of opportunistic behavior, we propose to consider the creation of common property goods (create and share what? and with whom?). We also propose to generalize the use of SMTA to minimize transaction costs and encourage the achievement of the innovations of tomorrow.

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