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INTELLECTUAL PROPERTY RIGHTS AND TECHNOLOGY TRANSFER IN DEVELOPING COUNTRY AGRICULTURE: RHETORIC AND REALITY

by

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RÉSUMÉ

La signature de l'accord sur les droits de propriété intellectuelle relatifs aux échanges (Accord TRIPS), entré en vigueur le 1er janvier 1995, a marqué un tournant dans les efforts entrepris pour renforcer la protection de la propriété intellectuelle. En vertu de cet accord, de nombreux pays en développement se sont engagés à étendre les droits de propriété intellectuelle à des domaines jusque-là non couverts, tels que les micro-organismes, le matériel génétique végétal et les techniques de manipulation génétique. L'impact probable de cette protection accrue de la propriété intellectuelle alimente un vif débat et, de fait, figure en tête des préoccupations relatives à la dégradation de l'environnement et à l'appauvrissement de la biodiversité. Toutefois, peu de travaux de recherche lui ont été consacrés.

Ce document passe en revue les diverses modalités et la portée des droits de propriété intellectuelle applicables aux transferts de technologie dans l'agriculture. Il fait le point sur les engagements pris par les pays en développement dans la cadre de l'accord TRIPS et sur les options dont ils disposent. Enfin, il met en lumière les conséquences possibles — positives ou négatives — du renforcement des droits de propriété intellectuelle pour les transferts de technologie et l'innovation dans l'agriculture des pays en développement.

SUMMARY

The signature of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement), which entered into force on 1st January, 1995, marked a turning point in efforts to strengthen and extend intellectual property protection. Under the terms of the Agreement, many developing countries are now committed to extending the scope of intellectual property rights to areas not formerly covered, such as micro-organisms, plant genetic material and techniques used for genetic manipulation. While the likely impact of strengthening intellectual property protection is a subject of intense debate and, indeed, has been at the forefront of preoccupations related to environmental degradation and the need to protect biodiversity, it is poorly researched.

This paper reviews the different forms and scope of intellectual property rights relevant to technology transfer in agriculture; reviews the commitments made by developing countries under the TRIPS agreement and the alternatives open to them. It then highlights the potential consequences — both positive and negative — of strengthening intellectual property rights for the transfer of technology and innovation in developing country agriculture.

LIST OF ACRONYMS

IPP	Intellectual Property Protection
IPR	Intellectual Property Rights
ASSINSEL	International Association of Plant Breeders for the Protection of Plant Varieties
UPOV	Union pour la Protection des Obtentions Végétales (International Convention for the Protection of Plant Varieties)
GATT	General Agreement on Tariffs and Trade
WTO	World Trade Organisation
PBRs	Plant Breeders' Rights
WIPO	World Intellectual Property Organisation
CGIAR	Consultative Group on International Agricultural Research (commonly referred to as CG)
IARC	International Agricultural Research Centre
TRIPs	Trade Related Intellectual Property Rights
OPV	Open-pollinated Variety
USDA	United States Department of Agriculture

PREFACE

The impact on developing countries of the strengthening of intellectual property rights as a result of the Uruguay Round TRIPS Agreement is a sensitive issue at the centre of a polarised debate. On the one hand, fears have been expressed that genetic resources originating in developing countries will be used in the development of new agricultural biotechnology-based techniques and products, to which access would subsequently be restricted by intellectual property rights. On the other hand, it is argued that strengthened intellectual property rights would increase the flow of technologies and products from developed to developing countries, as well as provide new incentives for local research and innovation.

This paper examines the ways in which technology transfer and innovation in developing country agriculture are likely to be facilitated or impeded by the strengthening of intellectual property rights to which countries are committed under the TRIPS Agreement. The consequences of a strengthened intellectual property regime are likely to be uneven, differing from one country to another in accordance with their level of agricultural development and their capacity to stimulate innovation in agriculture. Impacts are also likely to vary from one crop to another, between commercial and food crops and among different groups of farmers.

This paper contributes to the policy debate on access by developing countries to biotechnology products by clearly setting out the issues and discussing ways to narrow the gap between rhetoric and reality, including the need for further empirical research. Several avenues for government action are also suggested to realise better the potential benefits to developing countries of biotechnological advances, the outcome of which will be important for these countries' future agricultural development.

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I. INTRODUCTION

One important outcome of the Uruguay Round of international trade negotiations is the commitment, by all countries which are signatories to the final agreement, to strengthen intellectual property protection (IPP). For many countries, this aspect of the GATT agreement requires extending the scope of intellectual property rights (IPRs) to areas not formerly covered, such as micro-organisms, plant genetic material and techniques used for genetic manipulation.

The likely impact on developing countries of strengthening and extending IPP is a subject of intense debate. Since the Convention on Biological Diversity and the Trade-Related Intellectual Property Rights (TRIPS) Agreement entered into force (in December 1993 and January 1995 respectively), this debate has been at the forefront of preoccupations related to environmental degradation and the need to protect biodiversity[1].

On the one hand, fears have been expressed that genetic resources originating in developing countries will be used in the development of new agricultural biotechnology-based techniques and products, to which access will subsequently be restricted by IPRs. On the other hand, it is argued that strengthened IPRs will increase the flow of technologies and products from developed to developing countries. It is also argued that strong IPP will provide new incentives for local research and innovation. Although the impact of IPRs in developing country agriculture continues to be widely debated, the subject is poorly researched.

This paper is intended to fill this gap to the extent possible by reviewing available findings and setting out some of the key issues arising for developing countries. More specifically, its objectives are:

— to outline the different forms and scope of IPR relevant to technology transfer in agriculture;

— to review the commitments made by developing countries under the TRIPs agreement to extend and strengthen IPR protection related to micro-organisms, plant genetic material and techniques used for genetic manipulation;

— to highlight the potential consequences (both positive and negative) of strengthening IPR for the transfer of technology and innovation in developing country agriculture.

II. INTELLECTUAL PROPERTY PROTECTION AND PLANTS: FROM HYBRIDISATION TO TRIPS

The Extension And Strengthening of IPRs Related To Agriculture

In the age of the "information society" (OECD, 1995), information and knowledge are increasingly recognised as basic resources as essential to economic growth as energy or matter. However, information and knowledge have certain unique properties. Without information, nothing has meaning and all other resources are dependent on information (and knowledge) for their evaluation and utilisation. Furthermore, unlike energy and matter, information and knowledge resources are neither reduced nor lessened by increased use or wider sharing. In other words, knowledge is non-consumable (McHale, 1976).

IPRs can be defined as a set of laws devised for the purpose of protecting or rewarding inventors or creators of new knowledge. Precisely because knowledge, unlike consumable goods, can be shared by any number of persons without being diminished, creators are dependent on legal protection to prevent direct copying or the utilisation of the product or process they have invented without the payment of compensation. IPRs are thus intended to confer exclusive rights for inventors or discoverers, for a fixed period of time (Lesser, 1994).

The concept of protecting intellectual property is not new. In fact, according to Greek records, monopoly rights were granted to traders or inventors as early as 200 BC. Similarly, in mediaeval Europe, monopolies were granted to inventors and merchants in the form of "letters patent", or open letters addressed to the public. Patent-like privileges were granted from the 11th and 12th centuries, when production and marketing were organised around craftsmen and the guild system. Guilds, which provided monopoly for craftsmen products, later became examination boards for determining whether inventions were new or useful (Juma, 1989).

Since the Industrial Revolution, different forms of patent protection have expanded rapidly in a growing number of countries. Germany, for example, passed a modern patent law in 1877. This defined patentable improvements as new inventions which permit commercial use, but it excluded food, pharmaceutical and similar products from patenting.

Patent laws are of an essentially national nature. The first step in the direction of international harmonisation of IPRs was taken in 1883, when European and American advocates of the patent system participated in the International Convention for the Protection of Industrial Property, which took place in Paris. The Paris Convention became a landmark in the internationalisation of IPRs as it enshrined the principle of "non-discrimination". In accordance with this requirement, each contracting state must grant the same protection to nationals of other countries as it allows for its own citizens. Subsequent international agreements related to IPRs include: the Budapest Treaty, the European Patent Convention, and the Patent Cooperation Treaty[2].

By 1988, some 115 countries allowed patent protection in one form or another. Of those countries, more than 50 excluded biological inventions — plant and animal varieties — from protection (Lesser, 1991).

IPP related to plant genetic resources and plant varieties developed separately, due in part to the complexity and difficulty of protecting living matter. An important step in the direction of IPP was taken with the introduction in the United States in the 1930s of the first hybrid maize varieties. The new hybrid varieties, which produced considerably higher yields than open-pollinated varieties, could not be saved for sowing a second season without very considerable reduction in yield. Thus, farmers who had previously saved seed on-farm, were obliged to purchase the new varieties each season in order to maintain the increased yields. This afforded patent-like protection to the inventors or breeders of hybrid varieties.

As agricultural research and modern plant breeding developed, plant breeders also began to seek intellectual property ownership and protection over the product of their efforts, arguing that their contribution to society should be recognised in the same way as the contribution of industrial inventors.

Following the Paris Convention, plant breeders began to press for the equivalent of patents in plant protection. This led in the 1920s to the introduction of legislation in some European countries, and in the United States in the 1930s, to protect new plant varieties. The United States Plant Patent Act of 1930 allowed patent protection for asexually reproduced plants (not including tubers) only. Sexually-reproduced plant life was excluded due to its particularity of evolving and modifying over generations, making it difficult to determine what was originally patented.

The first international effort towards extending and harmonising plant breeders' rights (PBRs) took place at the 1956 congress in Austria of the International Association of Plant Breeders for the Protection of Plant Varieties (ASSINSEL). This led, in 1961, to the first International Convention for the Protection of New Plant Varieties (known by its French acronym, Union pour la Protection des Obtentions Végétales — UPOV).

While the forms of IPRs related to industrial and agricultural technology evolved separately, there has been a gradual but marked strengthening of IPP in all fields of innovation over the years. This has occurred in part as a result of growing concern over losses to patent-holders incurred by the infringement of IPRs, particularly in the form of copyright and brand-names.

At the same time, with the advent of biotechnology, the ways in which industrial and biological innovations are protected are converging, at least in OECD Member countries. An important step in this direction was taken with the landmark Chakrabarty vs. Diamond decision, taken by the Supreme Court in the United States in 1980, which allowed the patenting of a genetically-modified organism for the first time. The first patent application for a transgenic plant was filed in 1983, the first industrial patent for a plant variety awarded in the United States in 1985 and the first patent for a transgenic plant awarded in Europe in 1988. During the 1980s, the number of patent applications in plant biotechnology rose to some 250 per year (Joly, de Looze, 1996). At the same time, as illustrated in the discussion in Section III on the forms and scope of IPRs, the 1991 revision of the UPOV Convention brought PBRs further into line with patents.

United States insistence that the absence of comprehensive patent and other intellectual property laws constitutes non-tariff barriers to trade, led to the inclusion of “trade-related intellectual property” in the Uruguay Round of multilateral trade negotiations. Efforts to strengthen and extend IPRs led to the signature of the TRIPs agreement. This meant that the locus of discussion and negotiations on IPRs shifted from the technically-based work of the World Intellectual Property Organisation (WIPO), a UN body, to the newly-created World Trade Organisation (WTO).

New Concerns Regarding the Environment and Plant Genetic Resources

An epidemic of southern corn leaf blight in the United States in 1970, which resulted in huge crop losses, revealed that 80 per cent of the maize crop was susceptible to the disease. Following that incident, preoccupations regarding the protection of biological diversity, necessary for sustaining agriculture and food production — and, indeed, life — became a topic of international debate. At a time when new, high-yielding plant varieties were being rapidly introduced in developing countries, concern arose that the genetic uniformity of the new varieties would replace the variability and diversity of local varieties. Furthermore, it was feared that irreplaceable genetic resources were being lost and, as a consequence, concerted international efforts would be needed to conserve and protect these resources. During this period, the International Board for Plant Genetic Resources (IBPGR) was created by the Consultative Group on International Agricultural Research (CGIAR)[3] and the FAO Commission on Plant Genetic Resources was also established as an intergovernmental policy forum.

In 1983, the International Undertaking on Plant Genetic Resources (IUPGR), was established by FAO, as a non-legally-binding agreement for co-operation in the conservation of genetic material. An important aspect of this agreement was that, at the time of adoption, it was based on the "universally accepted principle that plant genetic resources are a heritage of mankind and consequently should be available without restriction" (FAO, 1983). In an effort to accommodate the concerns of countries providing breeders' rights for plant varieties and to reconcile the principle of free exchange with the protection of plant genetic material by PBRs, FAO adopted an "agreed interpretation" in 1989. This interpretation states that PBRs, as provided for under UPOV, are not incompatible with the International Undertaking. At the same time, it stresses that plant genetic resources should be freely available as a "heritage of mankind", while stating that "free access" does not necessarily mean free of charge (FAO, 1989).

The debate surrounding the utilisation and conservation of plant genetic resources was further complicated with the ratification of the Convention on Biological Diversity, which encompasses not only plant genetic resources, but all living organisms. In contrast to the FAO Undertaking, the Preamble to the Convention affirms that "States have sovereign rights over their own biological resources"[4].

The question of IPR and plant genetic material has thus become linked to "farmers' rights" in the case of the FAO undertaking, and, in the case of the Biodiversity Convention, to the "equitable sharing of the benefits arising from the utilisation of plant genetic resources". Despite the undertaking by the signatories of the TRIPs agreement to introduce IPRs of one form or another to cover plant genetic material, plant varieties and plant parts, opinions differ widely over the possession and control of genetic resources and the role played by IPR regimes. Our approach in this paper is to focus on the ways in which technology transfer and innovation in developing country agriculture are likely to be facilitated or impeded by the introduction of IPRs. It is nevertheless hoped that the paper will provide some insights relevant to the debate on access and benefit-sharing of the world's plant genetic resources.

III. THE FORMS AND SCOPE OF IPRS RELEVANT TO TECHNOLOGY TRANSFER IN AGRICULTURE

In the following paragraphs, the principal forms of IPRs are outlined and the differences and similarities between these forms are highlighted.

Patents, Including Petty Patents or Utility Models

The most common form of IPR is the patent (or utility patent) and, provided it complies with the requirements described below, any invention not expressly prohibited can be patented. Discoveries, scientific theories and mathematical formulae are excluded from patenting as are items considered offensive to public morals.

Patents may be granted for different kinds and levels of invention including: products; products-by-process; uses; processes (Lesser, 1991). Patents therefore apply to an ever-widening range of product and process inventions including, in a growing number of countries, selected living matter such as DNA sequences, genes, micro-organisms, plant parts and plant and animal varieties. Many developing countries, as well as a number of OECD Member countries, exclude pharmaceutical products and agriculturally-related products including plant and animal varieties, from patenting.

Rights Conferred by Patents

The granting of a patent confers monopoly rights on the holder, or inventor, over the use and benefit of an invention for a fixed period of time. Although the period differs from country to country, the duration of a patent usually varies between 14 and 20 years. During this time the inventor has the right to prevent others from producing, using, selling, offering for sale, or importing the invention, or to require a fee in return for the use (or licensing) of the invention (Lesser, 1991).

Requirements for Patenting

The granting of a patent is subject to the fulfilment of three conditions. These are: usefulness or industrial application; newness or novelty, in the sense that the invention was not previously known to the public; and non-obviousness, or inventive step, so that the invention constitutes an acknowledged extension of prior knowledge.

The condition of usefulness implies that mere ideas or concepts cannot be patented. In order to be patented, an invention must include a component of human effort that could — if applied — work as promised. However, the usefulness requirement does not necessarily imply practical application. It is sufficient that the invention works, not that it be practical in an economic or engineering sense.

The characteristic of novelty or newness requires that prior to applying for a patent, the invention was not known to society and in that sense, is something discovered for humanity.

To be patented, an invention must be "non obvious to a person skilled in the art". This requirement is intended to prevent patent claims on minimal modifications of known products or processes. The boundaries of minimal modifications on products or processes are not clearly defined and can be highly judgmental. The "inventive step" or degree of non-obviousness determines in part the scope of protection, particularly in the pharmaceutical, chemical and biotechnological fields.

Another important requirement for the granting of a patent is that of disclosure. This means that in applying for a patent, the invention must be described (or disclosed) with sufficient detail and clarity to enable a person "skilled in the art" to make and use the patent or to recreate the invention (Lesser, 1991). In the case of a growing number of inventions in micro-biology, disclosure alone is insufficient. Deposit of a sample of the biological material from which the invention has been derived will also then be required.

National Patent Offices are generally responsible for the granting or refusal of a patent application. The decision to allow a patent, or otherwise, is based on a process encompassing search and examination (or registration). A search needs to be conducted, either of national patent registers or through international agreements, to determine whether the claimed invention is indeed new. Examination of the claim is required to determine whether the invention is indeed sufficiently different (or non-obvious) from the prior state of the art to constitute an invention. Generally, the patent examiner will assume that the invention functions as claimed by the applicant. Patent offices do not usually attempt to test or otherwise evaluate the invention.

Registration may serve as an alternative to the examination system. With registration, an application is received and registered but no attempt to is made to assess the validity of the patent. Registration has the advantages of low cost and speed of operation as patents can be issued in much less time than that required — often years — by the examination system. It has the disadvantage of allowing invalid patents which could later be challenged in court.

Petty Patents or Utility Models

A limited number of countries allow another form of patent, the petty patent, otherwise referred to as utility model protection. While the requirements of novelty, industrial applicability (utility) and inventive step must still be met, they are interpreted differently. Petty patents are characterised, firstly, by a shorter duration of protection, usually between 4 and 7 years. Secondly, they are seldom subjected to examination and, thirdly, the inventive step required is minimal. In other words, a petty patent may be issued when only a modest improvement on existing products is provided (Siebert, *et al.,* 1990). A petty patent can be issued more rapidly and costs less than a utility patent.

Industrial Design

Finally, the industrial design (or, in the United States, design patent) provides another variation on patents. This form of protection applies to an invention's shape or form and the requirement for protection is novelty or originality of appearance, for which most countries use a registration system.

Compulsory Licences

Compulsory licensing refers to the provision of granting a licence to use a patented invention without the agreement of the patent owner. A compulsory licence may be granted on the grounds of "insufficient working" of the patent, in the case of dependent patents, or in the public interest, especially when related to health, nutrition or security (Lesser, 1991).

Trade Secrets

In most countries, trade secrets are not defined by national law or subjected to specific formal requirements, as are patents and other forms of IPR, although legislation allows those whose industrial secrets have been improperly acquired to use the courts to stop further use and/or seek restitution. Judicial interpretations of what can be protected as a trade secret have changed over time and are defined differently from one country to another. Trade secrets may be defined as information which confers a competitive advantage on the holder and which is therefore withheld from the public as a secret. Typically, trade secrets are protected by restricting access to the information through contracts and other agreements.

Trade secrets may either substitute for or increase the scope of patent and other intellectual property protection. Where they act as a substitute, the knowledge or technology constituting an invention is released under a contract which specifies the conditions of use and may require the payment of a royalty. Where they act as a complement to patents, trade secrets can be used to retain control over some additional aspect of the technology — "implicit" technology — which enhances the value of the patent. For example, the sale or transfer of complex technologies often takes the form of a package including one or more patent licences, trade secrets and management advice (Lesser, 1991).

The duration of trade secret validity is perpetual or until the secret is discovered by others or disclosed. Once a secret is lost, no protection applies unless it can be shown that the secret was improperly acquired. This is also true if valuable information can be deciphered by examining products in which the information is used, or by reverse engineering (Siebeck, *et al.,*1990).

The parental lines of hybrids, or particular reagents used in genetic manipulation may be protected by trade secrecy rather than patent or plant variety protection. Firms will often seek to protect their technology through trade secrecy when the technology is not already protected by other means.

Plant Breeders' Rights (PBRs)

Most countries — the United States being the exception — exclude agriculture-related inventions from utility patent protection, although a growing number of countries allow an alternative form of intellectual property protection —Plant Breeders' Rights (PBRs), otherwise referred to as Plant Variety Protection (PVP). In accordance with the UPOV Convention, which entered into force in 1961 and was revised in 1972, 1978 and 1991, the scope of PBRs is limited to new plant varieties[5].

Plant Breeders' Rights provide protection against the unauthorised use of the protected varieties. The requirements for plant variety protection are similar to those for utility patents but are less extensive in scope. Thus, they include: novelty, distinctiveness, uniformity or homogeneity, and stability. There is also a requirement that a variety be given a denomination by which it can be identified.

Novelty is determined by the fact that the variety must not have been offered for sale or marketed in the country of application, or in another country, for more than four years. To establish distinctness, which is the principal basis on which PBRs are awarded, the variety must be clearly distinguishable, by one or more important characteristics, from any other variety whose existence is a matter of common knowledge. Uniformity requires that important characteristics are uniform across a single planting and stability that the new variety reproduces true to form over repeated propagations[6].

In contrast with practice regarding patent applications, new plant varieties are generally subjected to official testing. In many countries, plant variety protection is typically administered by national organisations responsible for seed quality control and variety testing. In some countries, national patent offices both receive applications for and grant PBRs, but delegate the technical examination of new varieties for distinctness, uniformity and stability to specialists of the Ministry of Agriculture. In the United States, the protection of asexually reproduced varieties is the responsibility of the patent office, but the protection of sexually produced varieties is the responsibility of the Plant Variety Protection Office of the United States Department of Agriculture (USDA).

While PBRs are considered a weaker form of IPP than patents, each successive revision of the Convention has strengthened the scope of protection provided to plant breeders. The latest version, 1991, differs in a number of important ways from the earlier 1978 version. These concern, in particular, the scope and duration of protection, the rights of plant breeders, farmers' privilege and the concept of "essentially derived variety".

The Scope and Duration of Protection

Under the 1978 Act, member countries were obliged initially to provide protection for only 5 species, with gradual progression to a minimum of 24 plant species after 8 years. Under the 1991 Act (Article 3), countries are required to provide protection for all plant genera and species. Five years are allowed to reach this extent of protection for countries which are already members of the Convention, while for new members the period is extended to 10 years.

With respect to the duration of protection, under the 1978 Act protection was granted for a minimum period of 18 years for trees or vines, and 15 years in the case of all other plants. Under the 1991 Act, these minimum periods have been increased to 25 and 20 years respectively.

The Rights of Plant Breeders

The 1978 Act requires authorisation of the plant breeder for: the production of the reproductive or vegetative propagating material of the new plant variety for commercial purposes; the sale and marketing of the propagating material; the repeated use of the new plant variety for the commercial production of another variety; commercial use of ornamental plants or plant parts as propagating material in the production of ornamental plants or cut flowers.

In accordance with the 1978 Act breeders' rights cover the production and sale of reproductive or vegetative propagating material of the new variety, but do not extend to the harvested production (for example, the fruit from a protected variety of fruit tree). Similarly, breeders' rights apply to production for commercial marketing, but do not extend to production of propagating material that is not for commercial marketing. Thus the production of seed by a farmer for subsequent sowing on his or her own farm, which falls beyond the scope of the breeder's protection, is referred to as the "farmers' privilege".

Under the 1991 Act, the scope of breeders' rights extends not only to the propagating material but also to harvested material (including whole plants and parts of plants) or, in other words, to all production and reproduction of the protected variety. Countries are nevertheless permitted, on a discretionary basis, to exempt from breeders' rights traditional forms of saving seed on the farm which they may wish to retain.

Both the 1978 and 1991 Acts make provision for the so-called "breeder's exemption", which allows the use of a protected variety for research purposes, as an initial source of variation for creating other new varieties, without the authorisation of the breeder. However, the 1991 Act introduced the concept of "essential derivation" whereby varieties which are "essentially derived" from a protected variety can be protected but cannot be marketed without the permission of the breeder of the protected variety from which they are derived[7].

At present the 1978 UPOV Act remains in force. The 1991 Act will come into force one month after five States have deposited their instruments of adherence, provided that at least three such instruments are deposited by existing member states. It had been intended that, once the 1991 Act comes into force, the 1978 Act would be closed for further accessions. However, as a number of countries have initiated accession procedure on the basis of the 1978 Act, it has now been decided to leave the 1978 Act open for one year following the entry into force of the 1991 Act. In June 1997, 3 countries only had acceded to the 1991 Act: Denmark, the Netherlands and Israel.

The Potential for Multiple IPP of Plants and Plant Varieties

In many countries, and in accordance with the European Patent Convention (Article 53b), plant varieties, animal breeds and essentially biological processes for the production of plants and animals are excluded from patenting. At the same time, a growing number of countries allow patenting of the biochemical and molecular techniques used in the research and development of new plant varieties, particularly transgenic varieties. These include both the genes which encode the proteins responsible for a particular (transgenic) trait and enabling technologies. The latter include, for example: the plant transformation systems employed to insert specific genes into plant cells; selectable markers which are used to identify transformed cells; gene expression techniques which are used to ensure the proper functioning of inserted genes; and gene "silencing" techniques used to suppress gene expression (as in the Calgene Flavr Savr tomato).

Under the 1978 UPOV Convention, plant varieties could be protected only by means of PBRs but, under the 1991 Act, the simultaneous granting of protection to the same plant variety by more than one type of IPR, for example, PBRs and patents is allowed. The United States, which qualified for a special exception under the 1978 Act, has permitted both patents and PBRs for some time. Since different categories of IPRs can be applicable to agricultural technologies in each of the stages in the development of a plant variety — that is from the level of a micro-organism or gene to the newly denominated variety — it becomes increasingly likely that a single plant variety may be subject to several different patents and/or PBRs. And, it is to be noted, PBRs under the UPOV Convention, apply only to whole plants and to the propagating materials thereof.

Thus, as shown in Table 1, micro-organisms, genes, genetic markers, the processes or techniques used in tissue culture and in genetic engineering and transformation, as well as biotechnology end-products (seeds, plants, biopesticides/fertilisers) can all be the subject of IPRs.

Table 1. **Example of Multiple IPRS Related to the Development of One Insect-Tolerant Plant**

Subject	Components	Example	IPR
Plant Variety	Germplasm	Protected Variety	Plant variety right
Selectable marker gene	Promoter	35S	Patent
	Coding sequence	*npll*	Patent
Trait	Promoter	*TR*	Patent
	Coding sequence	*crylAb*	Patent
Transformation Technology	Ti-plasmid	pGV2260	Patent
Gene Expression Technology	Transcription Initiation	viral leader	Patent
	Translation Initiation	Joshi	-
	Codon usage	AT → GC	Patent
		Number of IPRs	8

Source: Suri Sehgal
"IPR-driven Restructuring of the Seed Industry" in Biotechnology & Development Monitor No. 29, December 1996.

IV. THE COMMITMENTS MADE UNDER THE TRIPS AGREEMENT

Major TRIPs Provisions and Exemptions

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) was concluded on April 15, 1994, and entered into force on 1st January, 1995. The TRIPs Agreement binds all members of the World Trade Organisation (WTO) to conform to certain standards regarding the availability, scope and use of IPRs. All the main areas of intellectual property, including copyright and related rights, trademarks, geographical indications, industrial design, patents, layout-designs (topographies) of integrated circuits, and undisclosed information are covered in the Agreement. Its stated objectives (in Article 7) are that the protection and enforcement of IPRs should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations.

Article 27 of the Agreement requires that patents be available for any inventions, whether products or processes, in all fields of technology, provided they fulfil the condition of being new, involve an inventive step and have potential industrial application. Patents are also to be available and patent rights enjoyable without discrimination with respect to the place of invention, the field of technology, or whether products are imported or locally produced.

Provision is made, nevertheless, for the exclusion from patentability of inventions considered a threat to "public order", and of diagnostic, therapeutic and surgical methods for the treatment of humans or animals. Plants and animals other than micro-organisms, as well as essentially biological processes for the production of plants or animals other than non-biological and microbiological processes may also be excluded. In the case of plant varieties countries are required to provide protection "either by patents or by an effective *sui generis* system or by any combination thereof".

Article 28 outlines the exclusive rights conferred on patent holders. These include both products and processes and relate to preventing third parties from making, using or selling the patented invention without the consent of the patent holder. In addition, patent owners have the right to assign or transfer the patent by succession, and to conclude licensing arrangements.

Articles 65 and 66 refer to special arrangements for developing country members. These concern, in particular, transitional arrangements, or the grace period which countries are permitted in order to comply with their commitments. The provisions of the Agreement should be applied by members within one year following the date of entry into force — 1st January 1995 — of the WTO Agreement. Developing country members are entitled to delay for a further period of four years.

The least-developed country members are allowed a longer period before application of the TRIPS provisions, up to 10 years. After that period, the TRIPS Council may accord a further extension.

The TRIPS Agreement also contains a provision allowing compulsory licensing (as indicated in Section III, a licence granted without the agreement of the patent owner). A compulsory licence may be granted to an applicant to use a patented invention where the patent holder has been unwilling to grant a voluntary licence on reasonable commercial terms and conditions within a reasonable period of time, but is subject to a number of conditions intended to protect the legitimate interest of the patent owner. In exceptional cases of public non-commercial use or in cases of national emergency, the requirement first to seek a voluntary licence may be waived.

The Roles of the Key IPR Institutions

The TRIPS Agreement in no way derogates from existing obligations which signatories may have with respect to each other under the provisions of the Paris Convention (for the Protection of Intellectual Property), the Berne Convention (for the Protection of Literary and Artistic Works), the Rome Convention (for the Protection of Performers, Producers of Phonograms and Broadcasting Organisations), or the Treaty on Intellectual Property in Respect of Integrated Circuits. The TRIPS Agreement is significant in that it implies a major shift in the locus of negotiations regarding IPRs to the WTO. Nevertheless, other relevant organisations such as the World Intellectual Property Organisation (WIPO) and UPOV will continue to play major — or even expanding — roles.

Established in 1967, WIPO became a specialised agency of the United Nations system in 1974. It has a mandate to promote the protection of intellectual property throughout the world by means of co-operation among States and, where appropriate, in collaboration with other international organisations. It also ensures administrative co-operation among the various intellectual property Unions, that is the "Unions" created by the Paris and Berne Conventions and several sub-treaties concluded by members of the Paris Union.

WIPO provides a range of services to developing countries related to intellectual property. These include: the provision of advice and training to governments and public and private sector organisations, on negotiations and arrangements relating to the licensing of intellectual property and the management of such property, where such arrangements have an impact on the environment. They also provide technological state-of-the art search reports covering various categories of technology. These reports, based on information published in patent documents, are provided free of charge.

On 1st January, 1996, WIPO and WTO entered into an agreement. This agreement provides that WIPO will continue to provide legal-technical assistance and technical co-operation activities for developing countries. It will also extend such assistance relating to the TRIPS Agreement to developing country which are members of WTO but may not be members of WIPO.

As in the past, WIPO's activities in favour of developing countries will continue to concentrate on industrial property law. The protection of plant varieties thus remains the province of UPOV, which will be required to play an enhanced role as more countries opt for PBRs rather than patents for the protection of plant varieties.

While membership of WTO and, hence, acceptance of the TRIPS Agreement, is almost universal, in August 1997, UPOV had only 34 Member states (see Table 2 below).

As indicated, membership of UPOV includes most OECD Member countries, with the exception of Greece, Iceland, Korea, Luxembourg and Turkey. The only non-member countries of OECD which are currently members of UPOV are: Argentina, Chile, Colombia, Ecuador, Israel, Paraguay, Slovakia, South Africa, Ukraine and Uruguay.

A growing number of countries in Eastern Europe, Latin America, the Middle East, Africa and Asia are preparing for accession to UPOV or are revising seed and plant protection laws. Some countries are opting for the provisions of the 1978 Act, others for the 1991 Act. Membership of UPOV is expected to expand rapidly, to around 50 countries by 1999 and to some 80 countries by the year 2000.

Table 2. **Membership of UPOV (as of August 1997)**

	State	Member since
OECD	Australia	March 1, 1989
	Austria	July 14, 1994
	Belgium	December 5, 1976
	Canada	March 4, 1991
	Czech Republic	January 1, 1993
	Denmark	October 6, 1968
	Finland	April 16, 1993
	France	October 3, 1971
	Germany	August 10, 1968
	Hungary	April 16, 1983
	Ireland	November 8, 1981
	Italy	July 1, 1977
	Japan	September 3, 1982
	Mexico	August 9, 1997
	Netherlands	August 10, 1968
	New Zealand	November 8, 1981
	Norway	September 13, 1993
	Poland	November 11, 1989
	Portugal	October 14, 1995
	Spain	May 18, 1980
	Sweden	December 17, 1971
	Switzerland	July 10, 1977
	United Kingdom	August 10, 1968
	United States	November 8, 1981
Non-OECD	Argentina	December 25, 1994
	Chile	January 5, 1996
	Colombia	September 13, 1996
	Ecuador	August 8, 1997
	Israel	December 12, 1979
	Paraguay	February 6, 1997
	Slovakia	January 1, 1993
	South Africa	November 6, 1977
	Ukraine	November 3, 1995
	Uruguay	November 13, 1994

Source: UPOV (Union pour la protection des obtentions végétales).

Special TRIPS Provisions Regarding Technology Transfer

In addition to the general objective of promoting innovation and the transfer and dissemination of new technology referred to earlier (Article 7) the TRIPS Agreement also contains some specific requirements for developed country members to provide incentives for technology transfer to least-developed country members.

The disclosure requirement of a patent application (that is, that applicants disclose the invention in a manner sufficiently clear and complete for the invention to be carried out by a person skilled in the art) has a number of important implications for the transfer of and access to technology. Firstly, information about from whom the technology can be obtained is readily available for the duration of the term of protection. Secondly, when a patent expires, the disclosed invention falls into the public domain and is freely available to all. Finally, Article 30, which refers to “limited exceptions” to the rights conferred by a patent, provides for the use of an invention for experimental — in other words, research — purposes.

The TRIPS Agreement also allows for cases where, if technology (whether patented or not) is in the control of a government, that government is free to transfer the technology on concessional terms if it so wishes. Similarly, there is nothing in the TRIPS Agreement which would prevent a government or international financial institution from providing financial assistance to permit the voluntary transfer of privately-held proprietary technology on concessional terms.

IPP Options for Plant Genetic Material

The TRIPs agreement leaves a number of technical issues which may arise with respect to the protection — and, particularly, patenting — of plant genetic material, open to question. An agreed legal interpretation on particular points may therefore be required on some points[8].

Under the terms of the agreement, members of the WTO which, at the time of signature, did not have an IPP system for plant genetic material and/or plant varieties in place, have a number of different options. These include:

— allowing the patenting of all plant genetic material, including plant varieties;

— allowing two forms of protection, as in the United States, that is patent protection for plant genetic material and PBRs or a *sui generis* system for plant varieties;

— excluding plant genetic material from patent protection and elaborating a *sui generis* system, or joining UPOV.

V. TECHNOLOGY TRANSFER IN AGRICULTURE: MECHANISMS AND AGENTS

Innovation in Agriculture

The argument used most frequently in favour of the strengthening of IPRs is that it will stimulate innovation. Monopoly rights conferred for a fixed period of time will enable an inventor to recuperate some of the costs incurred in the research and development leading to the invention. An appropriate IPR system, which provides innovators with economic incentives, will thus stimulate beneficial R&D (Horbulyk, 1993).

However, the impact of IPRs on technological innovation is still a somewhat neglected area of economic research. Of the limited research literature available, most has focused on industrial technology. As highlighted in Section VI below, the interaction between IPRs and agricultural technology — particularly with respect to developing countries and plants — remains very poorly researched[9].

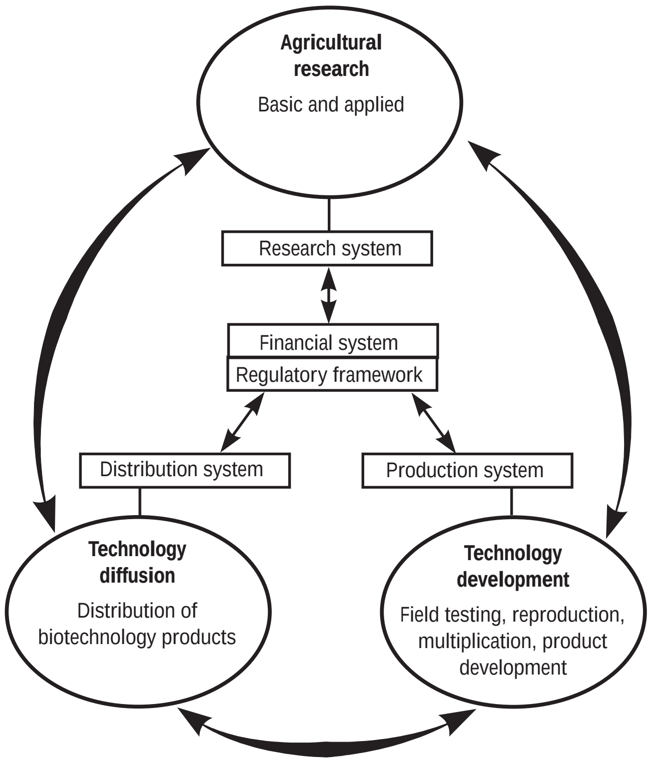
In agriculture, a number of different types of technology have contributed to truly spectacular gains in productivity — at least in the most technologically-advanced countries — of the past 50 or so years. Mechanisation, irrigation, the application of chemical fertilizers and herbicides have all contributed to increases in productivity and efficiency, as well as to unaccounted environmental costs. Plant breeding — or genetic — technologies have made a crucial contribution to increased agricultural production, particularly in developing countries, through the introduction of increasingly high-yielding varieties. Often, these different technologies have complemented one another. For example, the new varieties produced through conventional plant breeding would usually be complemented by the application of agro-chemicals, the introduction of improved tillage methods and irrigation.

Advances in the life sciences now offer new methods for agricultural diagnostics, plant virus and insect resistance, novel biocontrol agents, as well as genetic marker and mapping techniques as an aid to conventional plant breeding. It is therefore anticipated that, in the next 30 years or so, the new genetic techniques will make the key contribution to improvements in agricultural production, from both a qualitative and quantitative point of view. It is also hoped that the new biotechnologies will have a substitution, rather than complementary, effect in relation to some of the agro-chemical technologies, leading to more environmentally-friendly methods of agricultural production.

It has been common practice to patent mechanical and chemical technologies but, as pointed out in Section II, the system of IPP for living matter and biological techniques has developed differently and at a slower pace. In fact, in many countries — despite the commitments made under the TRIPS Agreement — genetic technologies are still excluded from protection.

Figure 1 provides a simplified conceptual framework for innovation in agriculture based on the concept of a national system of innovation. A national innovation system comprises a network of units, systems and sub-systems which interact to generate, exchange and distribute knowledge and technology. The framework encompasses **agricultural research**, technology **development** and **diffusion** which, as illustrated in the figure, are linked through the research, production and distribution systems. The different units, systems and sub-systems shown in Figure 1 function within the confines of a particular policy, financial and regulatory **environment**. The national IPP system is one element of that regulatory environment.

Figure 1. **Biotechnology in a National System of Innovation**



The effective functioning of the innovation system depends, *inter alia*, on the nature, frequency and intensity of transfers or flows of technology and information among the different units and sub-systems within the system. In principle, transfers of knowledge and technology take place at all phases in the process of bringing an agricultural innovation to fruition. These transfers take place in a variety of forms, between individuals as well as organisations, both public and private. (The various mechanisms for technology transfer are outlined in Table 3 in Section 3 below.)

The agricultural innovation process in industrialised countries — most notably in the United States — has been facilitated by intense interaction and feedback among the different parts of the system: individual research institutes; universities and industry; the scientific community and farmers; the traditional agricultural research community and biotechnologists; the public and private sectors. In many developing countries, the linkages among the different parts of the system are weak (Brenner, 1996). This is likely to inhibit, rather than facilitate, transfers of technology and information.

It is important to note that while Figure 1 illustrates the elements of a **national** — and, by implementation, closed — system of innovation, agricultural innovation systems are increasingly open. Elements of technology are thus transferred not only in a national context but, more and more, in a bilateral, regional or international context. In agriculture, there is already a long-established tradition of technology transfer between the international agricultural research centres (IARCs) of the Consultative Group on International Agricultural Research (CGIAR) and the national agricultural research systems (NARS) of developing countries.

The Changing Public/Private Sector Balance in Agricultural Innovation

A number of public and private actors and institutions are likely to be involved in innovation in agriculture, throughout the different phases of research, development and diffusion. These include, for example, in the public sector: relevant ministries (agriculture, livestock, education, science and technology); research councils and institutes and universities; parastatals involved in seeds, feed, animal health; the national extension system. In the private sector they include both commercial and non-commercial entities, for example: commercial seeds, agro-chemical and biotechnology companies; producer associations and co-ops; commodity boards; and non-commercial foundations (such as the Rockefeller Foundation) and non-government organisations (NGOs).

From the middle of the 19th century, formal agricultural research benefited from strong public support in many countries. Germany, Canada, the United States and Japan were at the forefront in setting up new agricultural research institutions and universities and in creating experimental stations. Before the end of the 19th century, public agricultural research was also being conducted by colonial administrations on tropical crops such as: oil palm, cacao, coffee, tea and cotton. In sub-Saharan Africa, for example, at least one research station or site had been established in virtually every country in the region by 1920 (Pardey, *et al.,* 1991).

In OECD and developing countries alike, the roles of the public and private sectors in agricultural innovation and — perhaps more significant — the balance between the two, are being transformed.

The Situation in OECD Member Countries

The role of the public sector in the financing of agricultural research and innovation has generally declined or stagnated in recent years in industrialised countries. This trend has been accelerated in recent years by increased private investment in the development of the new biotechnologies based on recombinant DNA technology, monoclonal antibodies, and new cell and tissue culture techniques. For 22 OECD Member countries; which account for more than 90 per cent of all developed country agricultural R&D, total public agricultural R&D expenditures increased from about $4.3 billion to about $7.1 billion (in 1985 international dollars) between 1971 and 193. However; while expenditures increased at an annual average growth rate or 2.7 per cent during the decade of the 1970s, these rates fell by around a third in the 1980s and early 1990s, to 1.8 per cent (Alston, *et. al* 1997).

In contrast; between 1981 and 1993, private sector agricultural R&D increased from $4 billion to over $7 billion, at an annual growth rate of 5.1 per cent. Privately performed agricultural R&D now accounts for almost half all OECD Member country agricultural R&D (Alston, *et al.* 1997).“

Taking the United States — the world’s largest investor in agricultural research — as an example, public expenditures on agricultural research rose by 3-4 per cent per year in real terms between 1940 and 1980, but since then, growth has slowed to 0.7 per cent per year. In contrast, private investment in agricultural research has tripled between 1960 and 1992. Expenditures on plant breeding research have grown from $6 million to $400 million, while expenditure on agricultural biotechnology, for which figures were not available in 1960, rose to $595 million by 1992 (Fuglie, *et al.*, 1996).

In the United States the private sector predominates in the development of new varieties for the major crop commodities. Some 3,307 Plant Variety Protection Certificates were issued for new crop varieties between 1970 and

1994, with soybeans, maize, wheat, cotton and vegetables accounting for the largest numbers. Of the total number of certificates for field crops, 84 per cent were issued to the private sector and 16 per cent to the public sector; for grasses and forage crops, 85 per cent to the private sector and 15 per cent to the public sector; for vegetables, 94 per cent to the private sector and only 6 per cent to the public sector; and for ornamentals, the figures are identical (Fuglie, *et al.,* 1996). One explanation for the very low share is that the public sector does not always seek to protect released varieties.

A second significant trend to be observed in industrialised countries is that of increased collaboration between the public and private sectors in research, technology development and dissemination, which may take a variety of forms. The Cooperative Research and Development Agreements (CRADAs) between federal research agencies and industrial partners in the United States are one example. By 1995, the number of CRADAs in which USDA was collaborating had reached 227, involving some $61 million of public and private research resources (Fuglie, *et al.*, 1997).

The Situation in Developing Countries

The pattern of declines in growth rates of public agricultural R&D expenditures has also been reflected in developing countries. Between 1971 and 1991, public expenditures on agricultural R&D increased from just under $3 billion to just over $8 billion. However, while expenditures grew at an annual rate of 4.4 per cent between 1971 and 1981, annual growth rates declined to only 2.8 per cent between 1981 and 1991.

Public agricultural research intensity ratios (ARIs), that is public agricultural R&D expenditures as a share of the value of agricultural output, remain low in developing countries compared with OECD Member countries. In 1991, the ARI for total developed countries was estimated at 2.39, compared with 0.51 for developing countries (Alston, *et al.,* 1997).

In contrast with the situation in OECD Member countries and despite pressures to reverse the trend, in most developing countries the public sector continues to play the major role not only in agricultural research but, in many cases, in technology development and diffusion also. Investment in agricultural research in developing countries grew very rapidly from the 1960s, but began to slow during the 1980s. Since the 1980s, a growing number of developing countries have adopted structural adjustment and liberalisation programmes, with consequent large-scale reductions in public expenditure and efforts to privatise economic activities formerly undertaken by the public sector. This has been reflected in stagnating or declining government budgets for agricultural research.

While the extent varies from one country to another, even in low-income countries, the public/private sector balance is evolving in favour of private enterprise. Public research institutes and universities are under growing financial pressure to seek private funding, to undertake research commissioned by the private sector, and to operate profitably. Similarly, in seed production and distribution, former public sector monopolies are giving way to growing private sector involvement. At the same time, particularly with respect to biotechnology, policy measures (such as tax incentives and soft loans) have been taken in a growing number of countries to provide incentives to commercial companies and to encourage public/private sector collaboration (Brenner, 1996).

The Case for Public Sector Investment in Agricultural Research and Innovation

The research and development (R&D) process can be seen as a continuum of activities, with basic scientific research at one extreme, followed by applied and adaptive research, with product development at the other end of the spectrum. Adaptive research can be important in agriculture, as elements of "transferred" or imported technology such as germplasm or a new seed variety, may require a lengthy period of adaptation to different agro-ecological and production conditions.

It is generally agreed, for both industrial and agricultural technology, that public research is necessary at the basic end of the spectrum. When it comes to applied and adaptive research, the situation is likely to vary according to the area of technology. Appropriability — that is the extent to which successful research results can be appropriated, or protected by IPRs — is likely to be a key determinant in investment decisions by the private sector (Thirtle and Echeverria, 1994). And in many countries, although the patenting of mechanical innovations is allowed, IPRs are not allowed, or are not yet in place, for genetic technologies.

In some areas, such as the collection and preservation of plant genetic resources, the case for public involvement and control is clear for environmental and other reasons. In others, there may be opportunities for complementarity or synergy between the public and private sectors in research and technology development. However, in other areas such as plant breeding and the seed industry, the private sector may produce and distribute seed based on material obtained — often freely — from the public sector. In the seeds sector in particular, there may even be overlap between the public and private sectors (Fuglie, *et al.,* 1996).

Arguments advanced in favour of a continuing role for the public sector in agricultural research in the United States are also valid for developing country situations. Firstly, publicly-funded agricultural research continues to yield high annual rates of return, (over 35 per cent in the United States) from which consumers, farmers and investors in agricultural industries all benefit. Secondly, public investment will be required, for example, in improved non-hybrid varieties, where not only are economic benefits limited, but also providing effective IPP is difficult. Finally, there is a compelling case for public funding in those areas of basic research (such as global climate change, food safety and quality) which, while offering little economic incentive, are important for informed decision-making (for example, global climate change, food safety and quality) (Fuglie, *et al., 1996)*.

Clearly, the role of the public sector must be expected to be greater in economies where markets are incomplete or undeveloped than where markets are well developed. It is therefore precisely in those situations where market failure is most pervasive that the need for the public provision of agricultural research and innovation will be most needed. In other words, this would apply in the case of biological technologies in a number of low-income countries where there are large numbers of small-scale, poor farmers.

A further justification for continued public sector activity — even in areas where the private sector should in principle be able to step in — is that the demand for agricultural technology is often poorly articulated in developing countries. Public research systems have often failed to determine, or to understand, the needs of their potential clients — particularly resource-poor farmers. This is, in part, because the linkages (see Figure 1) between major actors and institutions in the innovation system — for example, between public research institutions (including universities), industry and the farming community — which should provide accurate signals regarding demand for new technology are, at best, tenuous and, at worst, non-existent.

If, in addition to facing uncertain demand, returns to investment cannot be appropriated through IPP, the private sector is unlikely to play a significant role in research (Thirtle and Echeverria, 1994).

Technology Transfer Mechanisms and Agents

Mechanisms

Technology in agriculture may be transferred in many different forms, in a commercial or market context, in a non-market or “public good” context, or — as suggested by the foregoing discussion on the changing balance in public and private sector roles — by a combination of market and non-market mechanisms. Technology may belong to the public domain and be freely available to all, or it may be proprietary technology over which ownership rights or control (IPRs) are exercised. It may be transferred through the purchase of an end product (as seeds or machinery), or as an input into the agricultural research process (for example, a patented genetic mapping technique, or a patented gene).

The forms by which international transfers of technology are effected are numerous and include: information (including patent information) published in books, journals, newspapers and electronic media; movements of people through, for example, migration, technical assistance or the provision of experts; transfers of machinery and equipment; flows of capital for the purpose of setting up subsidiaries. Research literature which has examined international technology transfer in industry has used the following analytical categories: exports of capital goods or products; direct foreign investment; joint ventures; project exports; licensing; consultancy exports; and exports of skilled personnel (Lall, find reference). Little research has yet been done on technology transfer related specifically to agriculture and, in particular, to the transfer of plant genetic material which, for trade purposes, can be termed "genetic technologies".

Table 3 below, which lists the principal forms of technology transfer for genetic technologies[10] relates to transfers of technology both as an input into the R&D process (for example, a micro-organism, gene, or process) as well as in the form of an end-product (transgenic seed or planting material) at the diffusion phase of the innovation cycle. Although not always clear-cut, for purposes of clarity we have made a distinction between commercial and non-commercial transfers of technology. The term commercial does not necessarily imply the private sector because the public sector is sometimes involved in commercial transactions, and *vice versa*. It should also be recalled, as indicated in Table 1, that a single technology may be protected by more than one different forms of IPP.

Table 3. **Technology Transfer Mechanisms for Genetic Technologies**

	Form of technology transfer	Phase in innovation process
Market transactions	Purchase of technology (new seed variety, planting material)	Diffusion
	Licensing with royalty payments of product or process (e.g. diagnostic kit, mapping technique)	Research, development, diffusion
	Joint ventures	Research, development, diffusion
	Trade secrets (inbred, parental lines)	Research, development
	Collaborative research	Research, development
	Bio-prospecting agreements	Research, development, diffusion
	Materials transfer agreements	Research, development
Non-market transactions	Training and technical co-operation	Research, development, diffusion
	Collaborative research	Research, development
	Materials transfer agreements	Research, development
	Technology "donations"	Research, development
	Seed exchange among farmers	Diffusion

The relative importance of one form of technology transfer compared to another would, clearly, vary from country to country, in accordance with the state of development of their agriculture sector and as a function of effective demand for technology. However, little quantitative information is available regarding either the forms of technology acquisition by developing countries or the different forms of technology transfer between OECD Member and developing countries. A recent survey conducted by OECD yielded little statistical data (OECD, 1996).

With respect to genetic technology as products, the most common form of transfer is probably the purchase or import of seeds, principally for cereal and forage crops, fruit and vegetables, and planting material for floriculture products (Le Buanec, 1996). This would apply where countries have an important commercial farming sector, where a large share of planted area is sown to hybrids, where countries are major exporters of particular kinds of agricultural products or where countries have a dualistic system of production (large-scale commercial farming and low-income smallholders). While some small-scale farmers purchase seed and are engaged in profitable production, among low-income, low-input farmers, the major form of technology transfer remains that of the informal exchange of seed which has been saved on-farm.

Again, little published data is available on joint ventures, that is to say, joint ventures between companies from developed and developing countries, for the development of genetic technologies although anecdotal evidence suggests their numbers are increasing. The recent 50-50 joint venture between Plant Genetic Systems (since taken over by AgrEvo GmbH of Germany) and the Indian company ProAgro, set up to develop genetically-modified oilseed rape and other products is one example. A number of joint ventures in seeds production and plant breeding are also being formed, particularly for the production and marketing of hybrid crops (Sing, *et al.*, 1995)

With respect to genetic material for research purposes, the transfer or exchange of inbred or parental lines is known to be common among commercial companies in OECD Member countries. To illustrate, a seed company in, say, Germany might share inbred lines with a seed company in another country, usually under a trade secret arrangement. When it comes to the transfer of inbred lines from an OECD Member country to a developing country, this is most likely to take place where hybrids are involved and/or where the receiving country has already introduced PBRs.

Materials transfer agreements (MTAs) are also used extensively to transfer genetic material for research purposes. MTAs are commonly used in the framework of collaborative research, particularly in publicly or donor-funded research projects and programmes, where universities and/or public research institutions are partners. It is also the favoured form of technology transfer among and by the IARCs which, *inter alia*, are the designated custodians of the world's plant genetic resources. IARC agreements typically require that no IPR is sought, but do not include payment requirements.

A growing number of public/private sector partnerships for bioprospecting are being entered into by countries rich in biodiversity which wish, at one and the same time, to maintain control and ownership over their genetic resources and to earn revenue to be reinvested in research on their identification, classification and preservation. The country with the widest experience in bioprospecting is Costa Rica, which has negotiated a number of agreements for exploration of their genetic resources with industry partners, or with consortia consisting of private foundations, private companies, universities and the National Biodiversity Institute, INBio. In these agreements IPRs are negotiated on a case-by-case basis. Basically, the approach is to ensure: that Costa Rica shares the intellectual and economic benefits of technology transfer; that it enhances its capacity to add value to its biological and genetic resources; and that any profits from inventions and materials protected by IPRs — or from products derived from those protected inventions and materials — are shared by the various partners in such a way as to ensure further exploration and conservation in Costa Rica[11].

A final form of technology transfer of which there are now a limited number of examples is what might best be described as the technology "donation". This refers to situations where proprietary technology is "donated" to a developing country —and usually to a public research organisation or government — to be used under certain conditions. Two such examples are: the agreement between the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), Monsanto and the Centre of Research and Advanced Studies (CINVESTAV) in Mexico; the agreement between Ciba-Geigy (now Novartis) and the International Rice Research Institute (IRRI) in the Philippines, which is one of the IARCs. The first agreement, in which ISAAA served as intermediary, involved the transfer of Monsanto patented gene technology for virus resistance in potatoes to a public Mexican research institute. The second concerns the transfer of a synthetic *Bacillus thuringiensis* (Bt.) gene for insect resistance, patented by Ciba-Geigy, for use in transgenic rice research at IRRI. In both cases, the transfer was made as a royalty-free licence. In the latter case, rice produced with the Bt gene cannot be made available to rice producers in Australia, Canada, Japan, New Zealand, the United States and signatories of the European Patent Convention.

Agents

In technology transfer transactions between developed and developing countries, several different public and private partners may be involved. These may include national governments or government departments, NGOs and non-profit private foundations, the IARCs. Technology may also be transferred in the context of bilateral agreements between governments, through multilateral organisations, NGOs or non-profit foundations.

Since the diffusion of the “Green Revolution” technologies, the transfer of genetic technologies to developing countries has had a strong “public good” aspect, involving different public agents from developing countries, in partnership with both public and private agents from industrialised countries, together with private non-profit partners. Two key issues at stake following the TRIPs Agreement and the strengthening of IPRs are their impact, firstly, on both suppliers and final consumers of genetic technologies in developing countries and, secondly, on the existing international public good system for technology transfer in agriculture.

VI. IMPLICATIONS FOR TECHNOLOGY TRANSFER AND INNOVATION IN DEVELOPING COUNTRY AGRICULTURE

The discussion below on the potential consequences of strengthening IPR for the transfer of technology and innovation in developing country agriculture draws on available research literature. It needs to be emphasized, however, that little research effort has so far been devoted to this specific subject. It should also be stressed that IPRs alone, in the absence of a range of other supporting measures and institutions, will not be sufficient to stimulate technology transfer and innovation.

Overall Impact

Some researchers have in fact expressed doubts about the advantages, for developing countries, of introducing IPP. For example, in an effort to examine the welfare effects of global patent protection, one author uses a simple patent model to analyse the welfare effects of extending patent protection from the "inventor" country to the "consumer" country. The findings lead to the conclusion that, as patent protection is extended to more and more countries, global welfare effects diminish to the point of becoming negative. This leads to the conclusion that at least the lowest-income countries should be exempted from any new agreement to extend patent protection (Deardoff, 1992).

One comprehensive review of literature (Siebert, *et al.*) which covers different forms of protection, concludes that IPRs will entail both costs and benefits for developing countries which will vary from country to country. In other words, there will be some winners and some losers. The factors most likely to bear influence on costs/benefits include: the responsiveness of domestic innovators to higher levels of protection; the responsiveness of foreign direct investors; demand elasticities for protected products. Another study, again not confined specifically to agriculture, concludes that patents have positive impact in stimulating domestic inventive activity for adaptive inventions, particularly by local firms. It also concludes that PBRs appear to stimulate private investment in plant breeding, although only in a limited group of major crops (Lesser, 1991).

These findings on the overall impact of IPP concur with those of studies on the impact of PBRs in the United States, and one of the rare studies thus far conducted on developing countries. In the former case for example, of the total Plant Variety Protection Certificates granted for field crops between

1971 and 1994, almost 81 per cent concerned four crops: soybean, corn, wheat and cotton (Fuglie, *et al.*, 1996). In a study of five Latin American countries, in the case of Argentina which is one of the few countries where PBRs are effectively enforced, it was found that PBRs are having a positive effect on investment in plant breeding by domestic companies, with wheat and soybean the principal beneficiaries of research effort. In addition, public research institutes, which are now able to protect their material and new varieties, have benefited from licensing and royalty revenues (Jaffee, van Vijk, 1995).

One paper which examines possible IPR strategies for developing country agriculture, argues that IPRs may have a more beneficial effect on R&D in plant breeding than in industrial sectors (Correa, 1995). This conclusion is based on the concept of "technological distance" (whereby a technology which is "appropriate" in the sense of cost-minimising in Location A, may not produce the same results in Location B). This concept accommodates the conventional wisdom of the location-specificity of plant varieties. Thus, technological distance is large when technology requires major adaptation to be cost-effective in another location; it is small when the technology can be efficiently applied without significant adaptation. However, a recent study suggests that, at least for some major cereal crops, the issue of location-specificity has been overstated and that scarce resources could be used more effectively by strengthening regional and international research institutions (Byerlee, 1996).

The Costs of New Proprietary Technologies

The extension of IPRs for new crop varieties and for biotechnology innovations has raised concerns that the increased market power of private seed companies would result in higher seed costs to farmers. This concern arose in part as a result of two waves of mergers and acquisitions in the seed industry, the first in the late 1960s and early 1970s, when many small and medium-sized seed companies were acquired by large chemical, oil and food corporations, and the second during the 1980s, when a number of these large companies sold their interests to agricultural chemical firms. A study of the situation in the United States found that between 1975 and 1992, the real price of seed (as the ratio of the nominal seed price to the crop price) generally grew at a faster rate than yields. At the same time, prices for hybrid seed (corn and sorghum) rose more rapidly than prices for self-pollinated seed (Fuglie, *et al.)*.

From the evidence available it is difficult to identify clear trends with respect to trends in seed prices — particularly transgenic varieties — to farmers. In some cases, the price of transgenic seed is not higher than conventional seed. In others, seed purchase includes a "technology premium". For example, in 1996 the technology premium paid by farmers for Bt-based insect protection in cotton was over US$75 per hectare, and that for maize around US$32 per hectare.

A study of maize in India, where PBRs are not at present allowed, compares public and private sector seed prices, estimated in terms of the number of kilos of maize grain that must be sold to pay for one kilo of seed — the seed-to-grain price ratio. Table 4 provides estimates for 7 Asian countries. This shows that prices for hybrid seed are considerably higher than improved open-pollinated varieties (OPVs), often selling for two or three times as much. Private sector seed prices also tend to be higher than seed produced by the public sector, which of course may reflect subsidies paid to public seed production agencies. The study also found that public companies operated at a loss (Singh, *et al.*, 1995).

Table 4. **Seed-to-Grain Price Ratios in India and Selected Asian Countries**
(early 1990s)

	Public		Private	
	OPVs	Hybrids	OPVs	Hybrids
India	3.4	4.0	--	6.0
Indonesia	7.8	--	7.8	14.5
Pakistan	2.1	4.3	--	9.3
Nepal	2.0	--	--	7.5
Philippines	3.2	9.3	3.2	10.9
Thailand	5.5	14.8	6.0	16.7
Vietnam	2.5	14.5	--	20.0

Source: R.P. Singh, Suresh Pal, and Michael Morris, 1995, *Research, Development, and Seed Production in India: Contributions of the Public and Private Sectors*, CIMMYT Economics Working Paper 95-03, Mexico, D.F: CIMMYT.

Despite the higher seed prices, the share of the private sector in the Indian maize seed market is now over 50 per cent. In addition, growth in the volume of hybrid seed sales by private companies has been much more rapid than growth in the volume of the seed of open-pollinated varieties. Finally, growth in the volume of the seed of proprietary hybrids sold by private companies has been more rapid than growth in the volume of seed of public hybrids. This suggests that private companies are more effective at delivering their materials to farmers, particularly in the more favourable production environments (Singh, *et al.*, 1995) and/or that they provide seed of more consistent quality.

Access to Genetic Technologies

Concern has been expressed, particularly among NGOs, that developing countries will be deprived of access to new genetic technologies, directly when technology is protected by IPRs, and indirectly when they are unable to pay the higher costs implied. (It should be recalled that "access" to genetic technologies will concern both end products as well as inputs into the research process.) Another aspect of the issue of access is the concern of developing countries to retain control over the exploitation of indigenous genetic resources. In accordance with the terms of the Convention on Biological Diversity, developing countries may restrict access to these resources — for example, by companies of developed countries — unless they have first entered into a formal agreement on access (such as Prior Informed Consent agreements) and/or they are assured of a share in the benefits. To date, however, few countries have enacted national legislation to curtail access.

The foregoing paragraphs suggest that, in the case of the acquisition of new genetic technologies developed in industrialised countries, cost increases should be anticipated. In the case of seed, on which profit margins are generally low in developing countries, it is not clear what price increases could be sustained. In any event, cost increases would need to be weighed against the benefits to be derived from introducing the new technology: fewer crop losses from pests and disease and, possibly, increased yields.

Access to proprietary technology can be obtained through various channels, and from both commercial and non-commercial sources. In addition to outright purchase or licensing, the scanning of patent registers — due to the requirement of disclosure — can be a valuable source of technological information. Both patent law and PBRs also allow for a research exemption, so that materials on which an appropriated invention is based are made available for research purposes.

Access to proprietary technology can also be facilitated through joint public programmes and projects, for example between universities, through bilateral and multilateral development assistance, through the IARCs and through intermediaries or technology "brokers", such as ISAAA. Examples of technology donations, with or without the services of an intermediary, have been described in Section V. To date, however, there are few such examples and insufficient time has elapsed to assess the ultimate success or failure of these initiatives. Furthermore, as suggested below, national governments do have scope for negotiating terms of transfer of proprietary technology.

One important facet of access to technology — whether proprietary or in the public domain — which is often overlooked, is that the identification and selection of the most appropriate or most cost-effective technologies for a given situation require prior knowledge and skill on the part of the agent or country to which the technology is transferred. Technology transfer does not occur in a vacuum and can be effective only if it is transferred to an environment with adequate scientific and technological capability and infrastructure.

Impact for Local Innovators and National Innovation

One of the key issues at stake for developing countries is whether IPP is likely to enhance the role of local innovators and, by implication, strengthen national innovation capability.

The evidence referred to earlier suggests that private investment in research and plant breeding will be stimulated by the introduction of IPRs, but only for those crops where commercial demand exists. For open-pollinated varieties and for the crops of resource-poor farmers, it is unlikely that private companies will invest in R&D unless provided with incentives. It is also unlikely that IPRs alone would provide sufficient incentive to influence the behaviour of local innovators if other conditions, such as a generally favourable environment for investment, and for private sector development, were not met.

While it is true that in many developing countries agricultural R&D remains concentrated in public sector institutions, given current difficulties in funding public research, there is growing awareness of the need to stimulate private sector involvement. In a growing number of countries, different types of incentives are being offered to private firms (such as tax incentives, credit support, screening or testing services) either to stimulate public/private sector collaboration in research, or to stimulate the creation of local firms for the development of new technologies (Brenner, 1996) (Echeverria, *et al.*, 1996). While some of these efforts are still very tentative, it is a positive step in the direction of supporting the development of markets for genetic technologies.

The development of a private sector and the growth of markets for technology will not involve only local firms. Indeed, one of the most effective ways of acquiring not only the hardware aspects of technology, but also the more “tacit” aspects, is through different forms of collaboration or joint ventures with foreign companies. Even in the absence of IPRs related to plants, many of the major seeds and agro-chemicals companies — including those with major research programmes and at the forefront in genetic technologies — a number of MNCs have either set up subsidiaries or entered into joint ventures in developing companies. While the position of the MNCs on the need for strong IPP is unequivocal, many of these companies are operating in countries **without** IPRs in place. However, they are then usually involved in producing hybrids. Whether their product range would change with the acceptance of IPRs is unclear, but there is every reason to believe they would continue to be involved in those segments of the market where demand is most promising — and not in the crops produced by “resource-poor farmers”.

The ways in which public research institutions will be affected by the introduction and extension of IPRs are not straightforward. Public sector R&D is well-developed in a number of countries and, with structural adjustment and liberalisation, a growing number of public research institutions are under pressure to become involved in income-generating activities. Revenues from licensing or royalties, or from the provision of services, could therefore become important for those institutions which, until now, have made their “innovations” freely available to both public and private sectors.

It is clear that the need for public sector research in agriculture will remain, even where the private sector assumes a growing role in innovation. However, that role may need to be, if not redefined, at least more sharply focused. The introduction of a national IPP system may even facilitate a more rational public/private division of roles.

In certain situations, it may make eminent good sense, in both scientific and economic terms, for the public sector to purchase, license, or import particular elements of technology rather than “reinventing the wheel”. And, there can be certain undeniable advantages in being a latecomer or follower rather than attempting to lead the field or to “catch up” with a moving target: the technology which is acquired has been tried and tested, and can be obtained at lower price and with less risk. However, comparison of the costs and benefits of importing or purchasing genetic technologies versus local development is likely to be further complicated with the introduction of IPRs.

The fact that the new genetic technologies being developed in industrialised countries may not be the most appropriate for resolving the particular problems confronting agriculture in developing countries also needs to be taken into account. For example, herbicide-tolerance is unlikely to be a property sought after in low-input agriculture. If countries seek to develop genetic technologies designed to solve particular environmental or production problems, or targeted towards specific groups of producers, a number of options are open. Firstly, the technology can be an entirely local innovation, from the research to diffusion phase of the innovation cycle. Secondly, it can be developed locally from a combination of imported elements of technology and local germplasm. A third alternative would be to enter into research collaboration bilaterally, with a research consortium, or with a regional or international research institution.

Impact for the “Public Good” Technologies

The IARCs, some of which possess large collections of germplasm of a number of crops of importance to developing countries, entered into an agreement with FAO in October 1994. In accordance with this agreement, these collections have been placed under the auspices of FAO. All CGIAR centres holding plant genetic resources therefore hold this material in trust for the benefit of the international community and are not able to claim legal ownership. Furthermore, the Centres have agreed to “conserve, maintain, study, improve and distribute germplasm world-wide for use in agricultural research and development” (CGIAR, undated).

In the past, both the germplasm held in gene banks and material resulting from their own research, were made freely available both to developed and developing countries, as well as to both public and private sector research institutes and firms. For the CG system, the extension of IPRs poses delicate problems, as it raises the possibility of third parties obtaining either patent protection or PBRs on varieties derived from material supplied by the Centres. At the same time, it creates a dilemma for the Centres with respect to obtaining advanced material, or research techniques which could make a vital contribution to their own research effort, which may have been patented by private companies.

The ways in which the IARCs respond in situations where public good R&D has given way to proprietary technology is further complicated by the relevant autonomy of each individual institute in the system and the consequent difficulties of formulating a system-wide policy on IPRs. In the light of these difficulties a set of “Guiding Principles for the CGIAR Centres on Intellectual Property and Genetic Resources” has been drawn up. These are regarded as a set of interim guidelines, subject to periodic revision, rather than as formal policy of the CGIAR.

These guidelines allow for germplasm held by the Centres or for products of their breeding activities to be used by third parties for breeding purposes, without restriction. Recipients may protect the resulting products by PBRs, or *a sui generis* system, provided that the protection does not preclude others from using the original materials in their own breeding programmes.

While the Centres continue to consider the results of their research as “international public goods”, the possibility of seeking IPP is not totally excluded, and might be envisaged when it is needed to facilitate technology transfer or otherwise protect the interests of developing countries.

In those cases where cells, organelles, genes or molecular constructs have been isolated from materials supplied by the Centres, patenting — whether by public or private sector recipients — will require the agreement of the Centre which has supplied the material. Approval for patenting will be granted by the Centre concerned only after consultation with the country or countries of origin of the germplasm, when this is known. (This provision will comply with the “equitable sharing of benefits” provision of the Biological Diversity Convention, or of “farmers’ rights” under the FAO Undertaking.)

In those cases where Centres obtain elements of proprietary technology which have been patented by private companies, the Centres may enter into agreement with the patent-holders. Examples of such cases include an agreement between the International Potato Centre (CIP) and Monsanto; and the IRRI/Ciba-Geigy agreement referred to in Section V. Details of agreements between the IARCs and private companies are not generally known.

Two important questions concerning the future role of the CG system are raised by the strengthening of IPRs. Firstly, can it be expected that the IARCs will remain at the forefront in research on the crops under their particular mandate in the face of declining, or at least uncertain, financial support and without being able to benefit from IPR-related income-generating activities? Secondly, to what extent will a "global" public good system for research and technology transfer in favour of developing countries be able to co-exist with an increasingly global system of proprietary technology?

VII. CONCLUDING REMARKS

Rhetoric and Reality

The rhetoric surrounding the strengthening and extension of IPRs to all plant genetic material is useful in that it has focused attention on some of the potentially negative consequences. It is unfortunate, however, that the current state of research on the impact of IPRs on technology transfer and innovation in developing country agriculture is fragmentary and does not provide a sound basis for drawing conclusions. The findings reviewed in this paper do, nevertheless, throw some light on the rhetoric and reality of the current debate.

One conclusion which can be reasonably drawn is that the consequences are unlikely to be uniformly positive — nor uniformly negative — but will vary from one country to another, in accordance with their level of agricultural development and with their capacity to stimulate innovation in agriculture. Moreover, the consequences are likely to vary from one crop to another, between commercial and food crops and among different groups of producers. It is also useful to make a distinction between the implications of stronger IPR on technology transfer to farmers and on R&D incentives.

In the case of the transfer (or diffusion) of new technology products to farmers or other final consumers, if it is true that IPRs stimulate innovation and investment, a wider range and choice of technologies is likely to be available. For farmers who purchase a new seed variety, the question of price will be an important consideration, to be weighed against the advantages of the new variety, in terms of quality, yield, or resistance to pests or disease. For farmers planting a new seed variety, whether or not the seed is protected by IPRs is irrelevant, except where their previous rights either to save, re-use or exchange harvested seed are restricted. For example, if IPRs confer restrictions on the sale of harvested material where this was not previously the case, this may influence a farmer’s decision to plant the new variety. Even where a variety is not protected, purchase or sales agreements with seed companies can restrict farmers’ subsequent use of the seed.

In the case of the agricultural research process, whether basic, applied or adaptive, the impact of IPRs is unclear. Evidence suggests that IPRs provide an incentive for private sector investment in R&D. However, this is not necessarily seen as a positive development, particularly by those individuals, organisations, countries and cultures who have ethical difficulties about the possibility of patenting life forms, or strong reservations regarding the interest of commercial companies in providing appropriate genetic technologies for resource-poor farmers.

One rhetorical position is that IPRs — PBRs specifically — will lead to greater uniformity and consequently to a further narrowing of the genetic base of major crops. It is true that "homogeneity" is one of the requirements for granting PBRs and that farmers tend to replace the genetic variability of landraces with the more uniform protected varieties (or hybrids) which, at the same time, produce higher yields. This is a widespread trend even in countries which do not at present allow PBRs. It can be argued that market and agronomic forces rather than PBRs *per se* are the major factors leading to genetic erosion and the loss of genetic diversity. At the same time, it can be claimed that increased competition resulting from the extension of PBRs, will lead to more marked product differentiation among firms which, in turn, may enhance genetic diversity. PBRs may therefore play only a peripheral role in the erosion of genetic diversity.

Another concern is that IPRs will impede rather than facilitate the exchange of germplasm. With respect to flows of genetic material **from** developing countries, the Biodiversity Convention recognises the "sovereign rights" of States over their genetic resources and introduces the principle of "prior informed consent" where these resources are supplied to third parties. As we have seen earlier, the IARCs, which are the designated custodians of the plant genetic resources held in their gene-banks, continue to adhere to the principle of free exchange. Proponents of IPR argue that protection will **increase** the transfer of genetic material from developed to developing countries, but this remains to be seen. It is clear that the nature of exchange of germplasm for research purposes is changing from the former free flow to the transfer under different types of legal and/or commercial agreements. What is unclear is how this is likely to affect the volume of exchange.

Policy Issues and the Role of Governments

Developing country governments have a key role to play both in establishing an appropriate regulatory framework for IPRs and in formulating appropriate policies for stimulating technology transfer and innovation in agriculture. Although policy choices are far from straightforward, key elements of that role would include:

Complying with Commitments made under the TRIPs Agreement

Article 27 (3b) of the TRIPs agreement, which provides for the protection of plant varieties, will be reviewed in January 1999. Developing country signatories therefore have a very limited time frame within which to make decisions with respect to the options open to them and to elaborate protection systems designed to meet their particular needs and interests. A first effort to outline and evaluate elements which might constitute a TRIPs-compatible *sui generis* alternative to membership of the UPOV Convention has been conducted under the auspices of IPGRI (Leskien and Flintner, 1997).

In some instances, IPR legislation will require only marginal changes in existing laws, but in others it may be necessary to create new institutions and structures. IPR legislation will also require implementation, monitoring and enforcement and, consequently, financial resources as well as technical and legal expertise.

Creating the Right Policy Environment for Private Innovators

Stronger IPP is likely to act as one incentive, among others, to private sector research and innovation in agriculture. IPR legislation needs to be effectively implemented, however, and this is usually done by national institutions, through patent offices or, in the case of PBRs, through seeds sector institutions. These need to be strengthened in many countries. In addition to IPR legislation, a clear regulatory framework for the safe transfer of new biotechnology products is also required and, to date, few developing countries have adopted biosafety guidelines or legislation.

In those countries where markets for genetic technologies are undeveloped, additional incentives will be needed to encourage private sector involvement. Efforts to involve the private sector through the creation of public/ private sector partnerships — involving producer associations, small- and medium-sized local (or foreign) firms and NGOs — may need to be intensified.

Determining an Appropriate Role for the Public Sector

If innovation in agriculture is to be fostered at national level, public sector agricultural research will need to be more sharply focused in the future than it has been in the past. As there is little prospect of increasing total public investment in research — both domestic and donor funding — in the short-term, it is of increasing importance that the scarce public resources available should be used efficiently. For some countries, the private sector is already assuming a more active role in agricultural research and development and this trend should be supported.

In other countries, agricultural R&D remains almost solely a public sector activity. In these situations, public/private sector partnerships can be useful in facilitating the transition of development and production activities from the public to the private sector. However, as we have shown, with or without the introduction of IPRs, there are certain research and crop areas which are unlikely to attract private investment in the short term. The role of the public sector in research and innovation should therefore be twofold: to collaborate, where possible, in stimulating the involvement of the private sector; and to concentrate research effort on areas which are important for social or environmental reasons, but where there are unlikely to be short-term profits.

Negotiating Technology Transfer Agreements

Despite the trend towards the reinforcement of IPP, a very large share of existing technology remains in the public domain, either because protection has never been sought, or because the term of protection has expired. While a growing share of technology in agriculture may be transferred as market transactions, developing countries are also able to take advantage of projects and programmes which seek to facilitate technology transfer in agriculture as "international public goods". Many such programmes are supported through bilateral and multilateral development assistance, NGOs and by private foundations such as Rockefeller.

Even where technology has been protected there is scope for negotiation by governments. Nothing in the terms of the TRIPs agreement would prevent a government — or a donor or an international financial institution — from negotiating advantageous terms and/or providing financial and technical assistance to permit the transfer of privately-held proprietary technology on concessional terms.

The possibility of hiring the services of an "honest broker" — organisations such as ISAAA, competent NGOs, or independent experts — to act as intermediary in negotiating technology transfer terms between government authorities and private companies is also open to governments.

Research Needs

Under the terms of the TRIPs Agreement, developing country signatories are committed to introducing and/or strengthening national IPR systems and, more specifically, to extending IPP to plant varieties and/or plant parts. Despite these commitments, the question of whether or not the strengthening of IPRs will stimulate technology transfer and innovation in developing country agriculture remains to a large extent unanswered.

There is a pressing need for empirical research to address these issues. This could take the form of, for example: comparative country studies; studies related to specific products and/or technologies; studies on the ways in which the public agricultural R&D sector is responding to the challenge of the introduction of IPRs. There is also a need to reflect on the future prospects and role of an international public good system for agricultural research and innovation.

NOTES

1. For an overview of this debate, see The Crucible Group, *People, Plants, and Patents*, IDRC, Ottawa, 1994.

2. The 1997 Budapest Treaty on the International Recognition of the Deposit of Micro-organisms for the Purpose of Patent Procedure, relates to the recognition of deposit of living organisms in internationally sanctioned facilities. The European Patent Convention (EPC) applies to Member states of the European Union. The Patent Cooperation Treaty is intended to simplify and reduce the cost of obtaining patents in multiple countries through a single international application effected in one Member country, followed by an international publication and the international search report. These international patent agreements are administered by the World Intellectual Property Organisation (WIPO).

3. The CGIAR, established in 1971, is an informal association of more than 40 countries, international and regional organizations, private foundations, and representatives from national research systems in developing countries, formed to guide and support a system of international agricultural research centres (IARCs).

4. *Convention on Biological Diversity*, unep/CBD/94/2, Geneva, 1994.

5. "A 'variety' means a plant grouping within a single botanical taxon of the lowest known rank, which grouping, irrespective of whether the conditions of the grant of the breeder's right are fully met, can be:

   – defined by the expression of the characteristics resulting from a given genotype or combination of genotypes

   – distinguished from any other plant grouping by the expression of at least one of the said characteristics, and

   – considered as a unit with regard to its suitability for being propagated unchanged."

   Article 1 of the 1991 Act of the UPOV Convention.

6. See articles 6, 7, 8 and 9 of the UPOV Convention.

7. "With genetic engineering, it became theoretically possible for any variety to be transformed in the laboratory by the addition of one or more genes and for the transformed variety to be protected, if it was clearly distinguished from the initial variety, with no obligation to the original breeder on the part of the transformer." See *Why change the UPOV Convention? The Evolution of the Convention Resulting from the 1991 Act*, presentation of Mrs. Adelaide Harries, at the Information Meeting on the Protection of New Varieties of Plants under the UPOV Convention, Rome, April 19, 1996.

8. These points are outlined in detail in Dan Leskien and Michael Flitner, *Intellectual Property Rights and Plant Genetic Resources: Options for a Sui Generis System*, Issues in Genetic Resources No. 6, IPGRI, Rome, 1997.

9. See, for example: Wolfgang E. Siebeck, *op. cit.*; Walter G. Park, Juan Carlos Ginarte, *Intellectual Property Rights in a North-South Economic Context,* in: *Science Communication, Vol. 17, No. 3*, March 1996; Lesser, 1991, 1994, *op. cit.*; Walter Jaffé

and Jeroen van Wijk, *The Impact of Plant Breeders' Rights in Developing Countries*, Inter-American Institute for Cooperation on Agriculture, University of Amsterdam, October 1995; L.J. (Bees) Butler, *Plant Breeders' Rights in the U.S.: Update of a 1983 Study*, in *Intellectual Property Rights and Agriculture in Developing Countries*, Proceedings of a Seminar on the Impact of Plant Breeders' Rights in Developing Countries, March 7-8, Colombia, 1995.

10. These differ slightly from the types of technology transfer listed in *Intellectual Property, Technology Transfer and Genetic Resources*, OECD, Paris, 1996.

11. Ana Sittenfeld, INBio, personal communication.

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