Conservation and Use of Rice Germplasm: an Evolving Paradigm under the International Treaty on Plant Genetic Resources for Food and Agriculture

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Summary

Rice is the world's most important crop; the enormous diversity of its improved varieties, landraces, and wild relatives is the basis of daily sustenance for more people than any other single crop. The conservation of rice genetic resources and their use in plant breeding and research are fundamental components of a concerted effort to ensure global food security. This paper identifies the major national and international *ex situ* collections and describes their development and current conservation status, with an emphasis on the International Rice Genebank Collection (IRGC) maintained at the International Rice Research Institute (IRRI). It also reports on the state of characterization, evaluation, and documentation of rice germplasm. The value of rice germplasm to increase productivity is illustrated through its general use and through examples of particular genes that have been identified in germplasm accessions and subsequently used in breeding. Data are provided on trends in germplasm collecting and on access to and exchange of germplasm. In this context, particular attention is paid to access by national programs to improved germplasm through the International Network for Genetic Evaluation of Rice (INGER). The analysis concludes by examining some of the current developments affecting access to germplasm, including the effects of the development of access legislation under the Convention on Biological Diversity (CBD), legislation on intellectual property rights (IPRs), and other relevant national legislation.

The paper describes the International Treaty on Plant Genetic Resources for Food and Agriculture (IT), noting how it is designed to address some of the constraints relating to access by facilitating the exchange of germplasm. It also discusses the various aspects of benefit-sharing, as an incentive to *in situ* conservation and access for research and plant breeding, as well as to build up national capacities for the use and conservation of germplasm. Rice is one of the crops of the Multilateral System of Access and Benefit-Sharing (MLS) established by the IT, and the future management and use of the IRGC (as well as the other germplasm collections of the international centers of the Consultative Group on International Agricultural Research–CGIAR) are addressed in Article 15 of the Treaty. Current efforts to conserve and use rice germplasm illustrate the need for international cooperation in terms of both *ex situ* collections and *in situ* management, to support the aims of the Leipzig Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, adopted by 150 countries in 1996. Finally, the paper addresses the process of the interim committee pending the entry into force of the IT.

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Introduction: Rice and germplasm issues

Rice is the staple food of more than half the world's population. Rice production in Asia accounts for more than 90% of the world's total, and the balance is divided almost equally between Africa and Latin America, where demand for rice is increasing. Rice culture is ancient in Asia and for generations farmers have maintained thousands of different varieties (Jackson, 1995). These landraces and the 22 pan-tropical, wild species of *Oryza* are the genetic foundation for the breeding efforts needed to sustain the productivity of rice cultivation. Besides the landrace varieties and wild species already mentioned, the genetic resources of rice also encompass natural hybrids, commercial and obsolete varieties, breeding lines, and a range of different genetic stocks.

Most countries in Asia maintain collections of rice germplasm, and the largest are held in China, India, Thailand, and Japan[1]. Nigeria and Madagascar hold significant collections in Africa, while in Latin America, Brazil, Peru, Cuba, and Ecuador hold the largest collections. All these collections conserve both landrace varieties as well as breeding materials. Information on the extent of external access to these collections and their use in breeding (both nationally and internationally) is not easily available in publicly accessible databases. Four centers of the Consultative Group on International Agricultural Research (CGIAR), namely, the International Rice Research Institute (IRRI) in the Philippines, the West Africa Rice Development Association (WARDA) in Ivory Coast, the International Institute for Tropical Agriculture (IITA) in Nigeria (on behalf of WARDA), and the International Center for Tropical Agriculture (CIAT) in Colombia, also maintain rice collections. IRRI holds the largest collection; it is also the most genetically diverse and complete rice collection in the world (Table 1). Although the

Table 1. Origin of the accessions in the International Rice Genebank Collection at IRRI

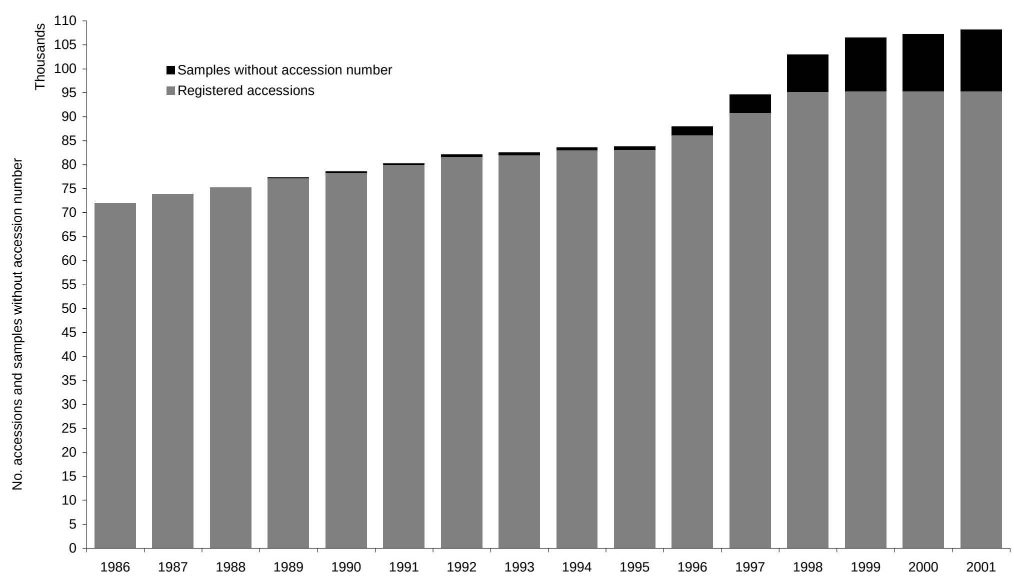
Country	Accessions
India	16,013
Lao PDR	15,280
Indonesia	8,993
PR China	8,507
Thailand	5,985
Bangladesh	5,923
Philippines	5,515
Cambodia	4,908
Malaysia	4,028
Myanmar	3,335
Vietnam	3,039
Nepal	2,545
Sri Lanka	2,123
Seven countries with >1000 and <2000 accessions	10,241
105 countries with <1000 accessions	11,821
Total	108,256

[1] http://apps3.fao.org/wiews/germplasm_query.htm?i_l=EN

WARDA/IITA and CIAT collections do have some specific regional representation, they are (to a large extent) duplicates of the germplasm conserved at IRRI, but they also have specific breeding materials developed at those centers.

How were these important collections assembled, and what is their status today?
Germplasm collecting in Asia has traditionally been a collaborative activity between the CGIAR centers and national programs; in Africa, collecting also involved French organizations such as the Institut de recherche pour le développement–IRD (formerly ORSTOM), the Institut de recherches agronomiques tropicales (IRAT), and the Institut des savanes (IDESSA), as well as the centers (Jackson *et al.*, 1997). From 1972 to 1993, IRRI scientists participated in 84 collecting missions in 17 countries, mainly in Asia, and almost 14,000 samples (predominantly cultivated

Fig. 1. Growth of the International Rice Genebank Collection since 1986.



rice) were added to the International Rice Genebank Collection (IRGC). However, from 1995 to 2000, with support from the Swiss Government, IRRI coordinated a major rice germplasm collecting project in 23 countries in South and Southeast Asia, sub-Saharan Africa, and Central America that added more than 25,000 samples of cultivated and wild rice to the IRGC[2].

The International Rice Genebank (IRG) at IRRI was established in 1977, although IRRI had begun to assemble a germplasm collection shortly after its foundation in 1960, to support its nascent breeding activities (Jackson, 1997). Today[3] the IRGC comprises 108,256 entries, with 95,318 registered accessions and 12,938 samples still to be registered in the collection with an accession number once sufficient seeds have been produced from a first multiplication at Los Baños. What is particularly interesting is that the collection grew by more than 31% after the Convention on Biological Diversity (CBD) came into force in December 1993 (Figure 1).

[2] http://www.irri.org/GRC/Biodiversity/Pdf%20files/Final%20report/Text/Contents.PDF
[3] At April 1, 2002.

Characterization and evaluation. The value of the collection was enhanced over the years through comprehensive characterization of the germplasm for 50 morphological and agronomic characters; over 90% of the accessions have received complete characterization, making it one of the best-characterized germplasm collections[4]. Together IRRI and the International Board for Plant Genetic Resources–IBPGR (now the International Plant Genetic Resources Institute–IPGRI) developed a list of descriptors for rice (*O. sativa*) that are widely used (IBPGR and IRRI, 1980). These descriptors have been updated to encompass all species of rice, not just *O. sativa*[5]. With breeders in the national programs, IRRI has published a Standard Evaluation System for Rice (IRRI, 1996).

Documentation. The volume of passport, characterization, and evaluation data is only really of value if researchers have access to them. Many genebanks have made great strides in recent years to improve their data management systems. Through the System-wide Information Network for Genetic Resources (SINGER), the CGIAR centers have placed all passport and some characterization data on the World Wide Web[6]. At IRRI, we developed the International Rice Genebank Collection Information System (IRGCIS), linked to SINGER and soon to be launched on the Web for external users. All data on the genebank collection will then be available, and users of germplasm will be able to request seeds electronically. The development of integrated data systems is very important to facilitate access to germplasm, to monitor how it is being used, and to provide information on its genetic value for breeding.

Links with rice breeding. In the CGIAR centers, the close connection between conservation of rice germplasm and its use in the breeding programs has catalyzed the comprehensive evaluation of germplasm for resistance to or tolerance for many pests and diseases (Jackson *et al*., 1997). Following the launch and success of IR8 in the 1960s—the first of the so-called "miracle rices"—there has been a continual stream of improved varieties and advanced breeding lines that have incorporated germplasm conserved in the IRG. A recent survey of pedigree data in the International Rice Information System[7] indicates that at least 10,000 IRGC accessions have been used in rice breeding worldwide[8].

Some very special sources of genetic diversity have been identified during germplasm evaluation. For example, a thorough evaluation of *O. sativa* germplasm failed to find resistance to the grassy stunt virus. It was found, however, in just one accession of the closely related wild species *O. nivara* (IRGC 101508) from India. IRRI breeders exploited this resistance and subsequently released IR36, at one time the most widely cultivated variety of any cereal (Swaminathan, 1982). Examples of germplasm use conferring a major impact, as did resistance to grassy stunt virus, are rather uncommon. However, just a cursory analysis of rice pedigrees, like that of IR36, shows how wide the search has been for new germplasm that may contribute to increased productivity in rice cultivation (Plucknett *et al*., 1987).

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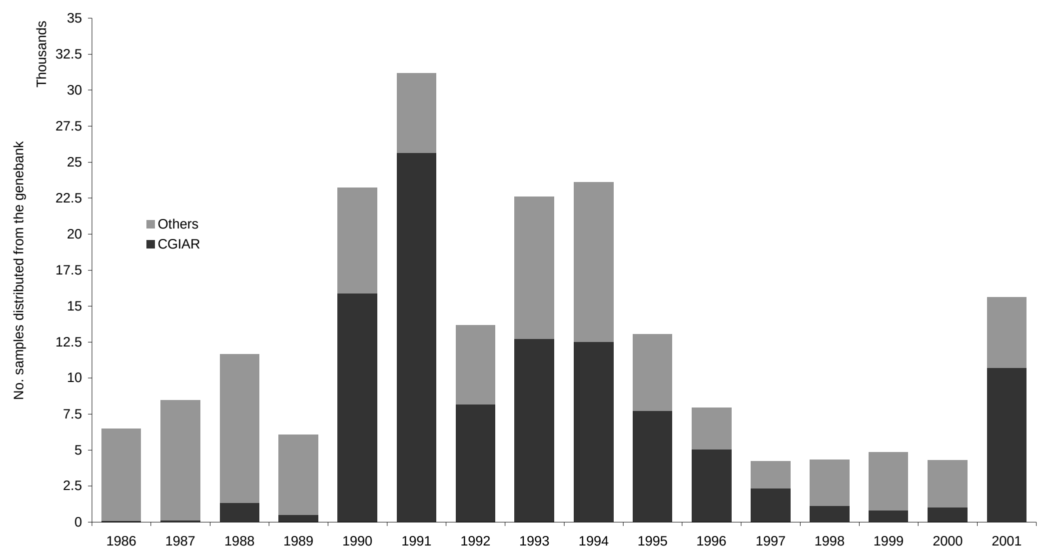
[4] http://www.irri.org/GRC/IRGmanual/Section5.PDF
[5] http://www.irri.org/GRC/IRGmanual/Section5.PDF
[6] http://singer.cgiar.org/
[7] http://www.iris.irri.org/
[8] Kenneth McNally (IRRI molecular geneticist), personal communication.

Germplasm collections in the international arena

In October 1994, the CGIAR centers placed their germplasm collections in trust in the International Network of *Ex Situ* Collections under the auspices of FAO, signing agreements that specified how the collections were to be maintained to international standards (FAO/IPGRI, 1994), as well as stipulating the conditions on access to and use of the germplasm. A material transfer agreement (MTA) was developed between FAO and the centers for all germplasm exchange. Under the agreement with FAO, IRRI designated all accessions that were currently registered in the collection (in October 1994), that is, all samples with an IRGC accession number—landrace varieties, wild species, and breeding lines and other genetic stocks. Two more designations were made after 1994, but only of accessions received at IRRI before December 29, 1993, when the CBD came into force. Germplasm received after that date is subject to the terms of the CBD and, apart from one accession of *O. minuta* from the Philippines, none has yet been designated formally to FAO, although all such germplasm is managed under the same terms and conditions as the designated accessions. In fact, several countries have expressly stated that germplasm samples they had donated post-CBD could not be designated to FAO. In any case, these samples have to be multiplied before being assigned an IRGC accession number. Since rice is an MLS crop under the International Treaty, all germplasm in the IRG will be managed under the terms of the Treaty when it comes into force.

Access to the germplasm. What has been the access to the germplasm in the International Rice Genebank, and who has requested it? Data are presented in Figure 2 for the years 1986-2001 (the years for which data are readily available electronically). Most of the requested

Fig. 2. Distribution of germplasm samples from the IRG since 1986.



germplasm has been used by CGIAR centers, primarily IRRI, in their breeding programs. Some 29% of all samples were sent to universities and advanced institutes around the world, and 10% to scientists from national programs in developing countries. Furthermore, from 1981 to 2001, 20,175 accessions were restored to national genebanks where germplasm had been lost for one reason or another.

Another interesting statistic is that more than 64,500 of the 95,000-plus registered accessions have been requested at least once during 1986-2001. This is indeed a high level of use of any genebank collection. On the other hand, only a rather small number of accessions have been requested from the collection time and time again, such as IRGC 328 (Azucena) and IRGC 12048 (Moroberekan), parental lines that have been used extensively worldwide in genetic mapping, genome, and breeding research. A few wild species accessions are frequently requested by rice researchers; indeed, the frequency of requests for wild species germplasm has increased in recent years, reflecting a growing interest in their use for breeding and biotechnology. Researchers in India and China requested most germplasm samples. Advanced institutes in North America, Europe, and Japan have also received many samples for basic research.

Germplasm exchange networks

Since 1975, the International Network for Genetic Evaluation of Rice (INGER), formerly known as the International Rice Testing Program (IRTP), has managed the exchange of improved germplasm between national programs and international centers. Through this important network, the wide-scale testing of elite lines is carried out, providing access to rich sources of rice germplasm among countries participating in the network. Since 1985, INGER has distributed more than 1,270,000 packets of seed and 13,756 nursery sets. Many of these entries have been used in national breeding programs—adding genetic diversity to one breeding pool from that developed in another country, and at no cost to the national programs (apart from the actual costs of running evaluation trials). Some have even been released directly as varieties in the countries where they were tested (Figures 3 and 4). National programs and international centers nominate germplasm for testing in particular nurseries under different environments and for resistance to different pests and diseases. In addition to INGER, breeders exchange among themselves elite breeding lines; IRRI breeders have sent almost 448,000 samples to

Fig. 3. Nursery sets distributed through INGER since 1985.

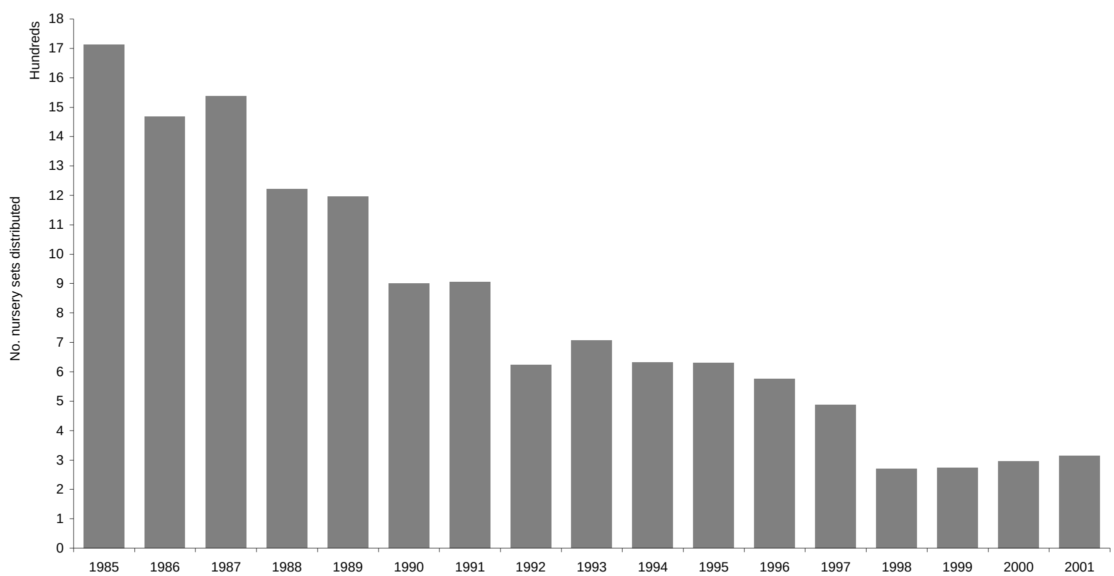
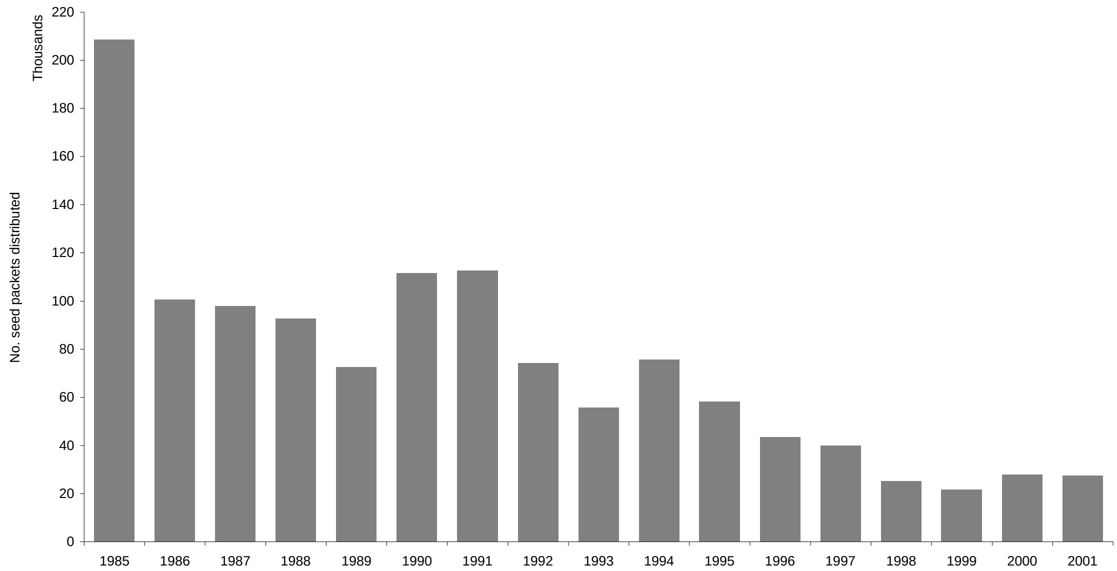


Fig. 4. Seed packets distributed through INGER since 1985.



breeders in more than 109 countries (an average of 46 countries per year) since 1986.

INGER has had an enormous impact, not only in genetic terms through the scale of germplasm exchange among national programs, but also in terms of the economic value ensuing in rice production and the benefit streams that accrue from the use of germplasm over time (Evenson and Gollin, 1994). The countries in Asia that benefited most from INGER are India, Thailand, the Philippines, and China. Through INGER, 62 national programs have released 559 pure-line varieties (371 unique genotypes) since 1975. In addition, nine INGER entries were used as restorer lines in 35 hybrid rice varieties in China from 1986 to 2000.

From its heyday in the mid-late 1980s, the scope of INGER has declined in recent years, the number of nominations of lines for germplasm lines is less, and the number of individual nurseries has been reduced based on the needs of national programs. This reflects to a certain extent the concurrent decline in funding for INGER since 1996, and the scaling-back of INGER operations in Africa and Latin America. Today germplasm exchange in Africa is handled by WARDA, and CIAT supports the Latin American countries. However, through the Fondo Latinoamericano para Arroz de Riego[9] (FLAR), a new model based on INGER for germplasm development, testing, and exchange for irrigated rice is supported by the private sector. But the slowing down of germplasm exchange may also reflect a growing reluctance among rice scientists to share germplasm as freely as they once did while uncertainties over germplasm ownership and benefit-sharing prevail, and the consequences of IPR legislation and mechanisms are not fully understood.

What is clear, however, is that countries have had extensive access to and benefited from the use of germplasm in international collections and germplasm exchange networks such as

[9] http://www.flar.org

INGER. The range of germplasm is much greater than what is available in national collections and most of their rice breeding programs.

Legal and policy aspects of the conservation and use of germplasm

In the second half of this paper, we look at the implications of current legal and policy developments in the field of germplasm conservation and use. Where possible, we use the example of IRRI, and its IRGC, as a case study, and highlight the fact that the International Treaty on Plant Genetic Resources for Food and Agriculture (IT) was specifically designed to overcome what were recognized as clear deficiencies in the international framework governing germplasm. Here we take a broadly chronological approach so that the developments of the last twenty years appear in context. Thus, we first consider developments in intellectual property rights regimes, then the entry into force of the Convention on Biological Diversity, and finally the IT.

Intellectual Property Rights (IPRs) and access to genetic resources

IPRs are temporary, state-granted, monopoly privileges for innovations that allow for the capture of benefits, usually financial, through a manipulation of market forces. Monopolies are normally frowned upon, where they are not illegal, in commercial activity as they eliminate competition and thus raise prices for products and services. A monopoly depends on an ability to exclude; if everybody has, or has access to, something, its economic value is minimal. The basic theory of IPRs is that the monopoly advantage acts as an incentive for innovation and, most importantly, for the disclosure of innovation. Thus, what society loses through lack of competition and higher prices is more than compensated for by the availability of a constant stream of innovations[10].

A key factor in the development of IPR policies—those related to biological innovations being a classic example—has been that IPR holders have increasingly sought strategically valuable rights as much as breakthrough ones. A breakthrough right has as its object an innovation that is independently valuable, such as the recent patent on a derivative of the *Hoodia* cactus as an appetite suppressant. A strategically valuable right is one that is either extremely broad, thus controlling all activities in the subject field, or one that blocks the activity of others in the field (Riley, 2000). The result is that the right holder can derive income from, or sometimes block, any other researcher in the field covered by their IPR. The classic example of strategically valuable IPRs was the Cohen/Boyer patents on rDNA technology held by Stanford University and the University of California. These IPRs effectively controlled all rDNA-related research and by their expiry in 1997, had generated more than US$200 million in royalties (Grubb, 1999). The Cohen/Boyer patents are a particularly interesting example as they point to the fact that this is not a purely private-sector phenomenon. A significant proportion of academic innovations involve facilitating technologies that are generally useful to researchers, i.e., technologies that naturally lend themselves to broad or blocking rights. Historically the prime motive of academic innovators has been to publish their results, thus making them freely available, but increasingly they, or more often their parent institutions, are seeking IPRs (Grubb, 1999).

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[10] Lettington, R.J.L., 2002. IPR: status and effects on international exchange of scientific information and germplasm. (Unpublished manuscript).

Prior to the 1980s, almost no countries allowed for IPRs (particularly patents) over plants or animals, and the question of genetic sequences was not really yet an issue. However, many developed countries did allow for the use of plant variety protection (PVP), normally consistent with the Convention for the Protection of New Varieties of Plants (UPOV). Only a handful of developing countries, such as South Africa and Argentina, allowed for PVP and almost none allowed for plant and animal patents, if they had patent legislation at all. Today most states, at whatever stage of development, have (or are about to adopt) some form of patent legislation, and frequently also a system of PVP.

The fundamental shift in this picture began with the case of Diamond vs. Chakrabarty in June 1980[11]. In its decision, the United States Court of Customs and Patent Appeals, with its interpretation of "anything under the sun that is made by man[12]", allowed for the patenting of microorganisms, and thus the great debate about the patenting of life forms began. Of course, this decision affected only IPR practices in the U.S. but, in combination with the rise of biotechnology in the 1980s, it contributed to a chain of events that culminated in the Trade-Related Aspects of Intellectual Property Rights (TRIPs) Agreement being part of the Uruguay Round package that gave birth to the World Trade Organization (WTO). TRIPs commits the more than 140 members of the WTO to provide minimum standards of IPR protection, including PVP by patent, an effective *sui generis* system or a combination of the two[13]. The connection among technological developments, U.S. legal interpretation, and TRIPs was the growing interest of industry in biological IPRs and the fact that the sector saw, in the Uruguay Round negotiations, a way to globalize IPR standards common in developed countries[14]. The main actor in realizing these ambitions, and arguably the principal author of the TRIPs Agreement, was the U.S. industry lobby group the Intellectual Property Committee[15].

This history has created a variety of effects on agricultural research. The most obvious are what might be termed "micro-impacts" and consist of specific cases. Thus far, there have been two main types of micro-impact, the moral and the commercial. On the moral side are the concerns of many groups that, to borrow a quote from President George W. Bush, life "is a creation, not a commodity"[16]. This referred to human life, but others hold that life forms in general should not be the subject of proprietary rights. Related to this are forms of spiritual objection, such as the ongoing controversy over the U.S. patent on the ayahuasca plant (*Banisteriopsis caapi*) that some people hold sacred in the Amazonian rainforests. A further set of questions relates to patents taken out over products derived from traditional knowledge, or

[11] Diamond v. Chakrabarty, 447 U.S. 303 (1980).
[12] Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980).
[13] Founder member Least Developed Countries are exempt from most requirements until 2006, the Developing Country exemption expired in 2000. There are no grace periods for new members.
[14] Drahos, P., 2001. Negotiating intellectual property rights: between coercion and dialogue. Paper presented at the *Oxfam International Seminar on Intellectual Property and Development: What Future for the WTO TRIPs Agreement*, held in Brussels, Belgium, March 20, 2001.
[15] Sell, S.K., 2002. TRIPs and the access to medicines campaign. Paper presented to the conference *Access to Medicines for the Developing World: International Facilitation or Hindrance?*, held at the University of Wisconsin Law School, Madison, Wisconsin, March 9-10, 2002. (Available from the author, email address: sellskgw@gwu.edu).
[16] Speech on human cloning to medical researchers at the White House (BBC World Service News, April 10, 2002).

knowledge in the public sector, such as in the cases of patents over neem or turmeric. Such controversy has both moral and commercial aspects. On the commercial side are U.S. patents involving basmati rice, enola bean, and quinoa, where the major concern of the objectors was the question of the limitation of export options for producers in the countries of origin, namely, India and Pakistan, Mexico, and the Andean region, respectively, and, in the case of basmati, the claims to a right to use a name with market value for a derived product produced elsewhere. An additional problem is that IPRs, in particular patents, can create control over the genetic sequences expressing the protected traits, and thus not only a particular variety is protected but all varieties containing those genetic sequences[17] (Correa, 2000). All of the cases cited involve IPRs granted in countries other than the country in which the genetic material originates, but, with the trend towards the increasing globalization of IPRs, national legislation in the most advanced countries increasingly conditions the situation in the less developed countries.

The real issue here is that the micro-impacts of developments in IPR practice, mentioned above, have created what might be called "macro-impacts". The possibility that germplasm will be privatized via IPRs has created an increasing reluctance in states, national agricultural research and extension systems (NARES), and civil society to provide access to it or regard it as being in the public domain. The fact that many theoretically public-sector institutions—universities being the most obvious examples—now engage in proprietary science dependent on IPRs means that both the public and private sectors are affected by this reluctance. Even public-sector institutions that are clearly not involved in proprietary science can be affected. Since they normally provide relatively easy access to their collections and research results, they are sometimes perceived to be at risk of acting as conduits, whether consciously or not, through which the products of nature can be accessed and privatized.

IPRs on germplasm create higher transaction costs in its exchange, and thus limit access (Correa, 2000). However, a wider problem is developing even where IPRs are not relevant, such as with wild or publicly available germplasm. Concern over IPRs in jurisdictions with very liberal interpretations of invention and novelty creates a fear of misappropriation and thus either blocks or, at a minimum, increases the transaction costs for access.

The Convention on Biological Diversity: Article 15–Access to genetic resources

Although it entered into force two years before TRIPs, the CBD can, in many ways, be seen as a response to it (Lettington, 2001). Not only were the negotiations for TRIPs largely complete before those for the CBD were truly under way[18], but the chain of events that led to TRIPs was clearly having an effect prior to the conceptualization of the Convention. It would seem that a significant motive for the inclusion of Article 15 of the CBD was a perceived need to balance the expansion of IPR over genetic resources (Correa, 2000).

The key features of Article 15 are its recognition of national sovereignty over genetic resources and the consequent establishment of a framework for agreements to grant access to

[17] It should be noted that most national interpretations of PVP do not create this broader control and restrict protection to specific varieties.
[18] Drahos, 2001.

these resources based on the concepts of prior informed consent and mutually agreed terms (Lettington, 2000). Article 15 can be seen as addressing concerns over misappropriation of resources by establishing a prior claim: national sovereignty[19]. The theory is that, in a state that has implemented Article 15 of the CBD, to do the research required to seek an IPR one must have obtained permission that, presumably, will include terms for benefit-sharing, including relating to IPR-potential products. Thus, in effect, the CBD balances the fear of privatization by misappropriation of the resources of marginalized actors by creating a parallel system of privatization favoring those actors. The key difference is that the ability to privatize under the CBD rests on the concept of country of origin rather than on economic and technological capacity, which are central to the ability to use IPRs.

The irony of this situation is, given the perceived tensions between TRIPs and the CBD, that the effect of the CBD on agriculture is very similar to that of TRIPs. Of course, this is not surprising when the CBD is seen as part of a continuum beginning with the expansion of IPR on genetic resources. The CBD is somewhat[20] effective in limiting asymmetries in the use of genetic resources, but in its dependence on the concepts of monopoly and market manipulation, i.e., limited access, under contract, it creates the same problem of either blocking access or increasing the transaction costs of access (Lettington, 2001).

While only a limited number of states have thus far introduced implementing legislation for Article 15 of the CBD, it is clear that the process is gaining pace. The Philippines was the first country to implement a full legal system, through Executive Order 247[21]. The Association of South East Asian Nations (ASEAN) has since developed a draft of a regional framework agreement for access and benefit-sharing. In Africa, several countries either have introduced or are about to introduce legislation or regulations and the Organization of African Unity (OAU)[22] has endorsed a model law that incorporates access and benefit-sharing provisions, among others. The situation is similar in Latin America with several draft laws on access and benefit-sharing near to adoption: Brazil having implemented regulations and Andean Pact Decision 391, the *Common Regime on Access to Genetic Resources*, having been in force since 1996. The Andean Pact has gone further by adopting, in 2000, Decision 486, *Régimen Común sobre Propiedad Industrial*, that introduces IPR provisions supportive of Decision 391, notably including a declaration of origin requirement.

In Resolution 3 of the Nairobi Final Act, adopted in parallel to the text of the CBD, the negotiating states noted that the CBD had not adequately addressed the needs of the agricultural sector, in particular the situation of *ex situ* collections and Farmers' Rights. Subsequent meetings of the Conference of the Parties to the CBD have built on this and, since negotiations for what is now the International Treaty on Plant Genetic Resources for Food and Agriculture (IT) began, have been supportive of the efforts taking place under the auspices of

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[19] National sovereignty can imply either individual or state rights, or some combination of the two, depending on the legislation or policies that a state adopts to implement Article 15.
[20] The current pressure from some states for a declaration of origin of any biological material that is the subject of a patent application suggests that some gaps in the system have already been identified.
[21] http://www.psdn.org.ph/chmbio/eo247.html
[22] Now African Union, since July 2002.

the FAO to develop a system of access and benefit-sharing that is specifically tailored to the circumstances and needs of agriculture.

The International Treaty on Plant Genetic Resources for Food and Agriculture

A tailored system of access and benefit-sharing for agriculture

The FAO Conference adopted the International Treaty (IT)[23] on November 3, 2001. It will enter into force upon ratification by 40 countries. The central feature of the IT is a system of access and benefit-sharing for plant genetic resources for food and agriculture that will ensure their conservation and sustainable use, while also promoting the exchange of the maximum diversity of germplasm for selected crops of major importance.

The importance of these objectives is highlighted by IRRI's experiences in rice improvement mentioned earlier. While there have been a few "magic bullet" experiences with significant individual impact, such as that with resistance to grassy stunt virus, the general picture is rather one of a slow building up of the desired traits, dependent on access to a broad range of germplasm. This is born out by the extensive use made of IRRI's IRGC and INGER system by a range of other institutions in various regions of the world. Apart from the use of IRRI's germplasm in research and breeding is the fact that the IRGC acts as a form of insurance for national collections. Not only are there the more than 20,000 duplicates restored to national genebanks, but the Lao PDR has even gone so far as to designate the IRGC as its long-term base collection. In many ways, these activities are the heirs to a phenomenon that has occurred over millennia: the cultivation of a diversity of varieties by small farmers and their gradual improvement through informal exchange and cooperation, whether directly or indirectly, at a global level (Lettington, 2001). It is this history that has created the interdependence of the world's regions for crop germplasm, one of the central principles of the IT[24].

The *raison d'etre* of the IT, and its most significant benefit, is that of the availability of germplasm for breeding. The Treaty revolves around an understanding that for the vitality of crops to be maintained, and for further improved varieties to be developed, the widest variety of germplasm must be available. The IT further recognizes that such a process is inevitably international because of countries' interdependence with regard to crop germplasm. The basing of agricultural germplasm exchange on bilateral principles creates a situation where comparative advantage defines relative abilities to capture benefits, but if one has no comparative advantage—and because of interdependence in agriculture no countries overall do—then one has no leverage to capture benefits, including access to the germplasm of others. The IT's solution to the problems posed by the bilateral exchange of germplasm is to shift the access and benefit-sharing mechanism to a multilateral level, in the form of the Multilateral System (MLS). Access to a selected list of crops and forages (identified as particularly significant, because of a combination of countries' interdependence and their role in global food security) will be available to all members of the MLS, i.e., parties to the Treaty. Thus, there is no need for individual negotiations and terms of access, as these questions are settled within the

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[23] The text of the IT, and the accompanying resolution on interim measures, can be found at http://www.fao.org/ag/cgrfa

[24] International Treaty on Plant Genetic Resources for Food and Agriculture, 2001; preambular paragraph 3.

text of the IT. The specifics of the benefit-sharing provisions that correspond with these access rights are discussed later in this paper.

Within the broad context of the problem of restricted access to germplasm that the IT seeks to solve is a series of more detailed problems, primarily, but not exclusively, associated with the nature of the bilateral systems of TRIPs and the CBD. The concern of potential germplasm donors about the downstream use, ownership, and future availability of their donations is addressed by the IT's provisions on IPRs and the commercial use of material covered by the MLS. The Treaty reiterates the normal IPR position on novelty, in that no material accessed from the MLS may be the subject of an IPR "in the form received" from the System. Any controversy over what "in the form received" actually means reflects the wider unresolved debate over the patenting of life forms. The MLS also contains provisions on the commercial use of material from the MLS. Where a commercial product incorporating material accessed from the MLS is not freely available to others for research and breeding purposes, the holder of rights over that product is liable for a mandatory royalty payment to the financial mechanism of the Treaty. The result is that the more liberal a jurisdiction's IPR standards, the greater the exposure of right holders within that jurisdiction to royalty payments.

At a more specific level, the IT seeks to solve a series of what might be called administrative and technical problems in the holding and distribution of germplasm under bilateral frameworks. The nature of these problems is most apparent when considered in the context of international *ex situ* collections. The first is simply a question of volume. If one considers that, as Figure 2 shows, IRRI has distributed from 5,000 to 30,000 samples from its genebank in each of the past fifteen years, the idea of arranging negotiations between the donor country and the recipient in each case, and enforcing them at law, becomes daunting. If one then also considers that during roughly the same period INGER has distributed more than one million packets of seed and more than 13,000 nursery sets, while IRRI breeders have supplied almost half a million samples of elite breeding lines to more than 100 countries, the numbers become overwhelming.

The negotiation of individual material transfer agreements, or licenses for access to proprietary material under IPR, is not a simple task. Contract negotiation of any kind can be among the most complex tasks in law, and, when that is combined with the need for advanced understanding of the technical issues involved with the use of germplasm, it is clear that a bilateral process is far from simple. Related to the capacity required to undertake such a task is the question of what that capacity costs. As noted by Visser *et al*. (2000) in relation to the *Transaction Costs of Germplasm Exchange under Bilateral Agreements,* even an assumption of a far lower volume of transactions than those of IRRI alone (including allowing for multiple transactions under single agreements), the potential costs run into the tens of millions of dollars per year. Critically, this estimate also does not allow for any monitoring or enforcement costs, something that would be necessary for the credibility of any bilateral system.

The activities of INGER and IRRI's breeders raise another question, that of whom one would negotiate with and how any benefits deriving from a bilateral agreement would be distributed. Improved varieties, elite breeding lines, and nursery sets do not come from a single source, they are composites of numerous improved varieties, and often landraces, from multiple sources, as the pedigree of IR36 so dramatically illustrates (Plucknett *et al.*, 1987). Thus, to correctly negotiate access, in response to the CBD, all of the countries of origin would presumably need to be identified and the value of their relative contributions assessed. As Fowler (2000) has noted, the question of country of origin is not always clear, and becomes highly subjective, depending on the criteria used. In addition, molecular data now indicate that the genetic contributions of parental lines in crosses are generally not equal[25]. Before negotiations for access began, one would therefore have to undertake the task of establishing criteria for countries of origin, determining the relevant countries, and assessing the relative value of each country's contribution to the proposed project.

To effectively implement a bilateral system of access to germplasm held in the *ex situ* collections of just the international agricultural research centers (IARCs), one is clearly talking about tens, if not hundreds, of millions of dollars in additional costs for each center, without considering the additional costs for those seeking access. In many cases, this implies more than doubling budgets because of activities that will rarely, if ever, contribute to the value of the output of research and breeding. The IT seeks to avoid this gargantuan bureaucracy through the MLS' establishment of standard terms and conditions for access to crops and forages covered by the system and, critically, to IARC collections in general. This relatively simple system means that IARCs can more or less automatically process requests for access, without having to undertake any research or negotiations. Since benefits all flow into the funding mechanism of the IT for multilateral use, there is also no need to enter into the complex, and prohibitively expensive, process of identifying countries of origin and relative values.

The IT thus represents an intergovernmental intervention that is designed to provide a solution to the potentially critical problems of a purely bilateral system for germplasm exchange in agriculture. First, it creates a multilateral system of access and benefit-sharing, in harmony with the CBD, in that countries agree to do so in the exercise of their sovereignty, to resolve the problem of transaction costs and the availability of existing germplasm. Second, where the use of germplasm covered by the multilateral system creates commercially marketed improved varieties covered by proprietary rights that affect future access for research or breeding purposes, a payment to the system is triggered. This mechanism reflects the rationale of IPR, that where a loss to society is created, there must be an alternative greater benefit.

The IT also gives significant recognition to Farmers' Rights, thus providing a basis for national measures to protect informal agricultural systems. This is of particular importance to the questions of saving and exchanging seed, and to the continued availability of public sector research support for such systems.

However, the biggest advantage created by the IT is that it allows public-sector institutions, and private ones to the extent that they wish, to avoid the costs of managing their germplasm on a bilateral basis, while guaranteeing access to a wide supply of germplasm from other sources. The MLS essentially constitutes one big trade for germplasm upon acceptance of its terms, a sort of germplasm club. This collective approach is not dependent upon the level or

[25] Edie Paul, personal communication. GENEFLOW Inc., 503 Mt. Vernon Ave., Alexandria, VA 22301–2243 (http://www.geneflowinc.com).

value of contributions to the MLS, and thus protects the future of all public institutions, regardless of size or geographic location, and traditional farmers as well as that of the small and medium-size private-sector breeders that would not have the economic power to leverage access in a bilateral system.

Benefit-sharing under the IT: capacity building and incentives for the conservation and sustainable use of germplasm

The IT recognizes the innate value of agrobiodiversity and the need for international cooperation in the management of both *ex situ* and *in situ* germplasm. While the primary benefit under the IT is facilitated access to germplasm for research and breeding purposes, there are a range of other provisions designed to assist germplasm-related activities in member states. As previously mentioned, the IT includes two financial aspects in its benefit-sharing strategy, commercial benefit-sharing and the financial mechanism, the latter relying primarily on donor countries. However, what is more important is the question of how the financial resources foreseen by the Treaty will be applied and augmented by other forms of benefit-sharing, such as technology transfer and capacity building. Central to this is the recognition of, and support for, the Leipzig Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture, adopted in 1996 by 150 countries[26].

The ability to consistently produce improved varieties depends on there being a broad base of germplasm from which desirable characteristics can be selected. An improved variety would not exist without the numerous predecessors that contributed to its development. The erosion of agrobiodiversity highlights the fact that continued availability can no longer be taken for granted and, since conservation costs money, these costs must be accounted for. The support provided by the IT is a first step in internalizing these costs that have traditionally been external to agricultural research and development. As a consequence, it is incorrect to see the Treaty's benefit-sharing provisions as a form of international aid, rather they should be viewed as "an insurance policy where industrial agriculture and the world's food consumers[27] are the insured while small farmers and developing countries are the insurer" (Lettington, 2001).

In such a situation, developing countries are clearly a priority for assistance under the IT. Not only do they contain a significant proportion of the world's *in situ* germplasm, critically including the largest number of small farmers cultivating landraces, but they also have the least ability to implement comprehensive strategies for the conservation of these resources. The Treaty envisions support for a range of activities fulfilling conservation goals but also stresses the need to support sustainable-use initiatives. This is likely to involve proactive projects that seek to develop the productivity of smallholder farmers without prejudicing the viability of the agrobiodiversity that they cultivate. There are obviously financial aspects to these provisions but the idea of cooperative activities aimed at capacity building is given at least equal weight.

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[26] http://www.fao.org/WAICENT/FaoInfo/Agricult/AGP/AGPS/GpaEN/gpatoc.htm

[27] "[T]*hose that spend money on food…*" as opposed to those that eat; page 58 in Tansey, G, 2000. Food security: a food system overview. In: M. Broggio and R. Kaukab (eds.), *The Geneva Documents: Proceedings of the Workshops on TRIPs, CBD and the International Undertaking.* Istituto Agronomico per l'Oltremare, Firenze, Italy. http://www.iao.florence.it/proceedings/geneva/geneva.pdf

The IT, primarily in its provisions relating to IARCs (in Article 15), but also as regards NARES, recognizes the need to place the maintenance of *ex situ* collections on a stable footing. The planned development of a Global Conservation Trust to endow international and national genebanks, as one activity within the IT's funding strategy, is an example of an initiative to fulfill these objectives.

Entry into force of the International Treaty on Plant Genetic Resources for Food and Agriculture

According to Article 28 of the IT, the Treaty will enter into force after ratification by 40 states. However, this does not mean that the agreement remains dormant until its entry into force. A resolution on interim measures[28], adopted in parallel with the text of the IT, states that the FAO Commission on Genetic Resources for Food and Agriculture will act as the Interim Committee[29] for the Treaty, until its entry into force and the convening of the Governing Body, composed of the countries having ratified the Treaty. The Interim Committee will do the preparatory work for the early decisions that the Governing Body is required to make. The tasks at issue fall into two broad categories, the first related to the exact mechanics of the IT and the second addressing the details of benefit-sharing strategies.

On the side of the mechanics of the IT, the most fundamental questions relate to the details of the standardized material transfer agreements that will govern the exchange of germplasm under the Treaty and the details of the agreements that IARCs will be invited to sign with the Governing Body regarding their *ex situ* collections. A further question is compliance, addressed by Article 21 of the Treaty: compliance will include "monitoring, and offering advice or assistance, including legal advice or legal assistance, when needed, in particular to developing countries and countries with economies in transition".

The outstanding issues relating to benefit-sharing essentially consist of establishing targets for proposed funding and priorities and strategies for how benefits, both financial and in kind, will be distributed. The Treaty clearly establishes the fact that benefits should be used to develop capacity in both the conservation and sustainable use of plant genetic resources for food and agriculture with reference to the Global Plan of Action. Small farmers and plant breeders are potential beneficiaries of the IT's activities. The former are likely to be a particular priority because of their prominence in the Treaty, deriving from Article 9 on Farmers' Rights. The IT also directs that the primary beneficiaries of any benefits that are available should be developing countries and countries with economies in transition. What remain are the development of detailed work plans and the establishment of longer-term priorities for assistance under the IT. The Interim Committee will develop draft documents on these questions for the consideration of the Governing Body.

The Interim Committee will have a significant effect on the activities of, at least, the first two meetings of the Governing Body of the IT. Thus, participation in the activities of the Interim Committee has clear potential benefits for states. Given that the activities of the Interim

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[28] Resolution 3 of the 31st FAO Conference, November 2001.

[29] The first meeting of the Interim Committee will be in October 2002 immediately following the ninth regular session of the Commission on Genetic Resources for Food and Agriculture (CGRFA).

Committee will examine fundamental issues of both implementation and benefit-sharing, there is a strong interest for both developed and developing countries, whether donors and recipients of germplasm or financial and technical assistance, or both. The Interim Committee has an open membership, but states that have either signed or ratified the IT will have a greater moral weight in discussions than those that have not.

The first 40 states to ratify the IT will make up the first meeting of the Governing Body and thus be able to make key strategic decisions regarding its implementation. It is therefore of great importance for countries to form part of the Governing Body at its first meeting, and therefore to ratify the Treaty as expeditiously as possible. Despite some uncertainties, the evolving paradigm for germplasm conservation and use under the International Treaty will ensure the continual availability of germplasm to enhance crop productivity, and benefit the livelihoods of farmers and consumers alike.

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