Centres of Origin, Distribution, Interdependence and Value

I. Introduction

In the best of all worlds, good policy is based on good science — and the science is clear and unambiguous and capable of providing relevant information and insights. In the real world, however, the results of 'science' often provide room for various interpretations, and even when unambiguous, science may yield to politics in policy- and law-making processes.

At the same time, technical and scientific considerations persist into the implementation phase, when policies must be operationalized and when laws must be interpreted, implemented and enforced. If the dissonance between science and policy is too great, pressures can build and eventually lead to changes in policy.

This session seeks to establish a common scientific base for our discussion of policies and laws by looking at certain topics that are central to contemporary policy and legal debates. These issues include, *inter alia*, the interpretation and use of the concept of 'origin', the current location of genetic diversity, the nature of contemporary germplasm flows, the degree of interdependence among nations for genetic resources, and the value that can be attributed to genetic resources.

II. Origins of plant genetic resources

N. I. Vavilov was a pioneering Russian scientist of the early twentieth century. Vavilov's legacy is a powerful one, in both a scientific and political sense. He postulated the existence of eight major Centres of Origin of cultivated plants. Vavilov recognized these centres as exhibiting tremendous diversity of a complex of crops. While Vavilov never used the term 'centre of diversity', we now recognize that Vavilov's centres were indeed centres of diversity that in many, but not all, cases corresponded to Centres of Origin for *groups* of crops.

In 1971, Jack Harlan published the first major critique of Vavilov, putting forth the view that there were both centres and 'noncentres' of domestication, some being so large or diffuse as to render the term meaningless.[1] Shortly thereafter, he observed in addition that 'it is becoming increasingly apparent that some [crops] do not have discernible centres either of diversity or of origin and that many have originated in areas outside of the centres of origin postulated by Vavilov. . . . Our studies have shown that most crops indigenous to Africa did not arise in a centre of origin in any conventional sense of a centre, and that the same situation is likely to have occurred in Southeast Asia and Oceania and in South America.'[2]

The Convention on Biological Diversity places great store in the feasibility of identifying a 'country of origin or a country that acquired the genetic resources in accordance with the CBD' of a species or a particular genetic resource. It is the country of origin of a specific

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1 Harlan, J.R. 1971. Agricultural Origins: Centers and Noncenters. *Science*, Vol. 174.

2 Harlan, J.R. 1975. Geographic Patterns of Variation in Some Cultivated Plants. *J. Heredity*, Vol. 66.

resource—and only that country—that, according to the CBD, is entitled to negotiate and approve terms of access with another party seeking access. This approach, designed primarily to deal with rare, endemic species of potential pharmaceutical, chemical or ornamental value, is of less utility when it comes to dealing with domesticated species.[3] The reasons for this will be explained below.

The CBD specifies that the country of origin of domesticated and cultivated species is the country where the genetic resource developed its distinctive properties in *in situ* conditions. Given the prominence of the Vavilov Centres of Origin, it may have appeared to negotiators of the Convention that identification of a country of origin of wheat, for example, would be as straightforward as ascertaining the country of origin of a rare orchid found in the Brazilian rainforest. This is not the case, however. In effect, Vavilov postulated geographic regions of origin (domestication) for groups of crops; the Convention speaks of (national) countries of origin for specific 'distinctive properties' of a particular crop, a far more precise criterion.

It is well known that crops were domesticated over vast expanses of land and over a long period of time, and that crops travelled as part of this process.[4] Pinpointing the location where a specific property arose (perhaps 10,000 years ago) may often be difficult, if not impossible. Moreover, most properties come in gradients: there are different shades of red apples, different sizes of bananas, different degrees of disease resistance, different levels of anti-oxidants in fruit, etc. Also, varieties incorporate a myriad of properties, each of which may have arisen at a different location and point in time. For some crops, the existence of secondary centres of diversity (such as Sub-Saharan Africa for maize and India for sorghum and millets) is recognized. All these factors reduce the practical value of using the Vavilov centres as the sole tool in determining 'origin' as used in the Convention.

The Vavilov legacy undoubtedly also influenced the negotiations on the International Treaty on Plant Genetic Resources for Food and Agriculture. In these negotiations, delegates established a multilateral system for some 35 crops and a number of forage plants, obviating the need (as in the CBD) to identify a precise country of origin for these materials. The selection of these crops and forages was based on their relevance for global food security and the mutual interdependence between countries on the availability of the genetic resources for these crops. In terms of crops excluded from the Multilateral System of the Treaty, one of the trade-offs that negotiators made was to 'give up' any Treaty-mandated collective benefits that would have been generated from existing *ex situ* (and *in situ*) collections of these crops in exchange for benefits they hoped individual countries might be able to capture from providing access bilaterally to these materials under the framework of the CBD.

As a consequence, all remaining crops—hundreds of them—henceforth need to be handled under the terms of the CBD. Delegates implicitly assumed that satisfying the requirements of the Convention—identifying the country of origin of specific distinctive properties—would be routinely feasible. Given our current knowledge about centres of origin and the location of origin of particular properties found within a domesticated crop, one might question whether this will be the case. On the surface, this would appear to be a case where 'the science' and the implications of the current state of knowledge were inadequately understood during the treaty-negotiating process, and where the limitations will become manifest as countries

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[3] Fowler, C. 2000. Protecting Farmer Innovation: The Convention on Biological Diversity and the Question of Origin. *Jurimetrics*, Vol. 41.

[4] It might be pointed out that many, perhaps most, developing countries are not included within the borders of any of Vavilov's original eight centres of origin.

attempt to implement both the Convention and the Treaty. However, at times in the negotiating process science might simply have yielded to political considerations.

III. The current location of diversity

Erna Bennett, a pioneer in the field of genetic resources, once jokingly remarked that if Vavilov were to redraw his maps, he would have to designate Ft. Collins, Colorado, as a centre of diversity. Ft. Collins is the location of the US National Seed Storage Laboratory, one of the largest genebanks in the world. The observation is an appropriate one in the context of policy and law making in which countries attempt to pair 'access' with 'benefit sharing' in a manner that depends on the laws of supply and demand. While it is certainly true that all genetic resources originally came from *in situ* conditions, it is equally obvious that much of that diversity can no longer be found 'in the field', *and* that a great deal of diversity can now be accessed from genebanks far removed from any Vavilov centre. As Table 1.3.1 reveals, some of the best potential 'customers' for PGRFA are also likely to be the biggest suppliers or sellers. The implication — the lesson to be learned — is that access and benefit-sharing schemes designed to regulate current transactions need to take into account not so much the historical location of materials as their present location and status.

Table 1.3.1. Number of genebanks and number of accessions in *ex situ* collections, by region

Region	No. of accessions	% of Total	Genebanks	% of Total
Africa	353 523	6	124	10
Latin America and Caribbean	642 405	12	227	17
North America	762 061	14	101	8
Asia	1 533 979	28	293	22
Europe	1 934 5744	35	496	38
Near East	327 963	6	67	5
Total	5 554 505	100	1308	100
CGIAR	593 191		12	

Source: FAO. 1998. The State of the World's Plant Genetic Resources for Food and Agriculture. FAO, Rome, Italy.

Crop experts believe that much of the existing diversity has already been collected and is maintained in genebanks. This is particularly the case for major staple crops such as rice, wheat and maize. FAO has estimated that 95% of the landraces of these crops can be found in *ex situ* collections.[5] Of course, landraces continue to evolve in the field, giving the possibility that new genetic combinations, or mutations, of value will arise. Conversely, genetic erosion is also taking place, giving the possibility that existing (and new) materials will be lost.

In addition to the figures provided above, one needs to consider the quality of the collections and the associated information that can be provided about them. Many collections located within Vavilov centres, or developing countries more generally, are of relatively less utility than their numbers might indicate, having been compromised over the years by less than adequate conservation practices and facilities. The reported need for regeneration is often high, for example, and this may be seen as indicating that storage conditions may be poor and that diversity may have already been partly lost.

[5] FAO. 1998. The State of the World's Plant Genetic Resources for Food and Agriculture. FAO, Rome, Italy.

Finally, plant breeders in the private sector tend to depend primarily on their own advanced varieties and those of their competitors when breeding new varieties. Only where such varieties do not contain traits that are required, may plant breeders turn to farmers' varieties and wild relatives of crop species to search for those traits. The reason for this strong preference is that it generally takes a lot of effort to integrate the desired traits in the preferred current genetic background of commercial varieties.

All of these considerations must be taken into account when assessing which sources are and will be most important in supplying genetic resources for future breeding programmes. Data provided here indicate, however, that much diversity exists and can be more easily accessed from sources outside traditional Vavilov centres, a situation that may undermine the 'market' position of 'countries of origin' under the CBD.

IV. Germplasm transfers

Academic work on contemporary germplasm transfers reinforces the view that *ex situ* collections 'in the public domain' are important as sources of materials for both developed and developing countries.[6] CGIAR centres, for example, distribute some 100 000 samples per year, and it has been estimated that national genebanks may distribute a similar number, both nationally and internationally.[7]

There is also strong evidence that access from *ex situ* sources far exceeds access from *in situ* conditions, if collecting by CGIAR centres is any indication of the overall situation.[8] CGIAR centres now add substantially fewer than 5000 accessions (predominantly but not exclusively from *in situ* sources) to their collections per year, less than 5% of the amount that is distributed from their *ex situ* holdings.

In addition, the fact that CGIAR centres have 'restored' germplasm in recent years to at least 41 countries that had previously provided the same accessions to the centres and that upon request, various national genebanks have undertaken similar initiatives is evidence that many countries are losing materials (and thus, would not be in a position to provide them or to benefit from providing them).

Once again, the objective reality may therefore intervene in the desire to directly obtain benefits from providing access to plant genetic resources. Most materials may already be in storage and in the public domain outside of the countries in the centre of origin. And, there may be little relative demand for, or current economic value associated with, materials found exclusively in *in situ* conditions.

Given these 'realities', countries are faced with both a number of options and a number of dilemmas. They may wish to consider (1) how they will secure access to the materials they need in an efficient and cost-effective manner, and (2) how they will provide access to materials they have in a way that maximizes benefits to themselves. These goals may prove to

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[6] Fowler, C., M. Smale and S. Gaiji. 2001. Unequal Exchange: Recent Transfers of Agricultural Resources and Their Implications for Developing Countries. *Development Policy Review*, Vol. 19, No. 2.

[7] Visser, B., D. Eaton, N. Louwaars and J. Engels. 2000. Transaction Costs of Germplasm Exchange under Bilateral Agreements. Global Forum on Agricultural Research, Dresden, Germany.

[8] System-wide Genetic Resources Programme (SGRP) of the Consultative Group on International Agricultural Research. 1996. Report of the Internally Commissioned External Review of the CGIAR Genebank Operations. IPGRI, Rome.

be somewhat contradictory in practice, leading to a third option, which is to consider cooperative measures. This third option assumes (1) that countries are interdependent in terms of genetic resources, and (2) that access is important — or will become important — to all.

V. Interdependence

No country is predominantly independent in terms of PGRFA. For the same reason that few, if any, countries are the sole source of genetic resources for a particular crop, all countries depend on others, even for access to materials of crops native to their own country. Many countries, however, have agricultural systems based chiefly on crops that were domesticated elsewhere, and on genetic resources supplied by others.

Countries in southern Africa, for example, fall between 65% and 100% in their dependence on main food crops that originated outside the region, with most countries exceeding a 90% dependency level.[9] Generally, dependency is higher for developed than for developing countries, though often the levels are remarkably similar. According to FAO, Italy has a dependency level of 71%–81%. The country that most closely matches this level is Ghana with a dependency of 70%–81%.

Dependency on *crops* that originated outside of the country should not, however, be confused with dependency on *access* to those crops. As we have already seen, in reality the source of the genetic resources of a particular crop might bear little relation to the region or the country where the crop originated.

Interdependency is graphically illustrated by looking at the pedigrees of modern varieties of major food grains, for instance. The wheat cultivar, Sonalika, which was planted on over 6 million hectares in developing countries in 1990, has a pedigree drawing on materials acquired from no fewer than 15 countries. Sonalika is far from being unique. Major spring bread wheats (planted on more than 0.25 million hectares) in the developing world in 1997, *on average* had 50 landraces in their known pedigrees and were the result of nearly 2000 parental combinations.[10]

Several conclusions can be drawn from such data:

1. Clearly, both international and national programmes use large amounts of material, based on genetic resources supplied by many countries.
2. Assigning an economic value to individual accessions would be difficult, given the number of accessions used and the number of crosses made to produce a certain variety. This difficulty, combined with other factors, such as the ease of duplication and the multiplicity of sources as a result of the spread of crops over 10 000 years, explains the historic absence of a market for PGRFA as a commodity.
3. Benefits are captured, however, even if the genetic resource is not directly sold as such as a commodity. Materials are used in breeding programmes, value is added in the research process, and countries, farmers and consumers benefit by having better and more productive varieties. Byerlee and Traxler (1995) estimate that the benefits just from wheat breeding for spring bread wheat in the developing world

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9 Palacios, X.F. 1998. Contribution to the Estimation of Countries' Interdependence in the Area of Plant Genetic Resources. Background Study Paper No. 7. FAO, Rome.

10 Cassaday, K., M. Smale, C. Fowler and P. Heisey. 2001. Benefits from Giving and Receiving Genetic Resources: The Case of Wheat. *Plant Genetic Resources Newsletter* No. 127.

were approximately US$2.5 billion annually by the late 1980s.[11] Similarly, it has been argued that the investments of the United States in the maize breeding programme of CIMMYT are exceeded by the additional income that the United States has derived from access to the improved CIMMYT maize germplasm. None of this benefit, interestingly, is realized in the form of income generated by providing access to PGRFA. Arguably, the principal value of the genetic resource is as a resource, not as a commodity. One of the challenges now faced by policymakers is thus how to develop appropriate policies based on this understanding.

While 'access' is obviously critical to plant breeding programmes, it is also critical to farmers who use improved seeds and planting materials in various ways and to various degrees, depending on their needs and possibilities. Farmers may prefer to buy seeds in the market, whether produced commercially or locally, or they may maintain their own seed stocks. However, also in the latter case, farmers may routinely seek access to seed with which to develop and improve their own varieties. Thus, both directly and indirectly, access is important to *all* countries in which a crop is grown, even to those without active plant breeding programmes in that particular crop. There is no example of a country being able to develop its agricultural system on the basis of reliance on either indigenous crops or on genetic resources sourced exclusively locally. Countries that are looking at all toward the future and are at all optimistic about or desirous of creating a prosperous agricultural system must be appreciative of the value of having access to genetic resources from others.

VI. Conclusion

Struggles over crops, planting materials and genetic resources are ancient. Countries and interest groups have long manoeuvred to gain advantages from the flow of genetic resources. Various strategies have been employed, some collective, some highly individualistic. Successful management of PGRFA in the 21st century will certainly benefit from a knowledge of this history, but it will benefit even more from an understanding of current realities and current needs, characterized by a high level of interdependence. In this session, we have looked at the ability of modern science (and relatively recent theories such as Vavilov's) to underpin certain approaches to managing access and benefit sharing (e.g., those of the Convention on Biological Diversity and, in relation to crops covered by the Multilateral System, of the International Treaty on Plant Genetic Resources). Since plant breeders access materials not from history books but from existing collections and sources, we have asked where genetic diversity can be found and most easily obtained today. The conclusions we arrived at have further been confirmed by data on germplasm flows. Finally, we looked at the nature and degree of dependence that countries have on outside sources of germplasm.

Strong policies and beneficial laws are founded on good science, and to a large extent, implementation absolutely depends on it. Policies and laws predicated on anything less than a solid factual basis contain 'structural faults' that will lead to unanticipated consequences, and probably to correction or even their own undoing at some point in the future. This session has looked at certain key issues that affect how policies and laws (in particular the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources) will be implemented. In so doing, the objective has been to provide the groundwork for a discussion about how well such policies and laws will achieve their own objectives, in light of the fact

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[11] Byerlee, D. and G. Traxler. 1995. National and International Wheat Improvement Research in the Post-Green Revolution Period: Evolution and Impacts. *Am. J. Agricultural Economics*, Vol. 77(2).

that their drafting may not always have taken sufficient account of certain ‘realities’ discussed in this section. How then, can future policies and laws — and implementation of existing international agreements — be improved to achieve the admirable goals of the CBD and the International Treaty, i.e., the conservation and sustainable use of PGRFA and the fair and equitable sharing of benefits arising out of their use?