

# Germplasm Flows Between Developing Countries and the CGIAR: An Initial Assessment

By  
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## Introduction

It is well known that most major agricultural crops were domesticated over a period of thousands of years in what are now termed “developing” countries. Historically, the greatest concentration of genetic diversity has consequently been found in developing countries. The “flow” of genetic resources from these developing countries to Europe and North America – a process which took place over hundreds, and in some cases, thousands of years – unquestionably provided the early biological foundations for agriculture in today’s developed countries. Developing countries have also come to rely heavily on non-indigenous crops and thus on imported germplasm. Countries in Southern Africa fall between 65 and 100% in their dependency on main food crops that originated outside the region, with most countries exceeding a 90% dependency level.<sup>4</sup> Since countries in this region lack both large *ex situ* collections as well as a broad base of modern varieties of the crops on which they depend, future agricultural development will clearly require secure access to genetic resources of maize, cassava, wheat, rice, beans, plantain, banana, and potato.<sup>5</sup>

The question facing both developed and developing countries today is whether to encourage the flow and use of genetic resources through a multilateral system, or restrain their exchange as would inevitably happen were access handled through myriad bilateral agreements. Some commentators have pointed to the historic transfer of genetic resources from South to North as evidence of “biopiracy,” and implied

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<sup>4</sup> Palacios, Ximena Flores (undated). Contribution to the Estimation of Countries’ Interdependence in the Area of Plant Genetic Resources. Background Study Paper No. 7, Rev. 1. Rome: FAO Commission on Genetic Resources for Food and Agriculture. Palacios measured the degree to which an individual country’s food energy supply (measured in calories) was dependent on crops whose primary area of genetic diversity was found outside of that particular country.

<sup>5</sup> It is also interesting to note that countries that are not dependent on non-indigenous crops are typically countries that are not normally considered well-endowed in terms of PGRFA of interest to the international community. Niger, for instance, is between 13-27% dependent according to the Palacios study for FAO. Niger, however, might not be able to take advantage of this lack of dependency, because it would still have few marketable genetic resources of interest to other countries. It should also be noted that Niger is the least dependent African nation. The median level of *minimum* dependency on non-indigenous major crops is 73%. In terms of maximum dependency, as defined by Palacios, Angola, Comoros, Djibouti, Kenya, Madagascar, Malawi, Mauritius, Seychelles, South Africa, Swaziland, and Zambia, all fall above 97%. Ethiopia, the country generally considered the richest in PGRFA in Africa, is estimated to be between 28-56% dependent.

that the North's gain has come from the South's loss. They argue that developing countries might, even today, be better served through bilateral systems of access and/or a multilateral system of restricted scope. Greater control over access would, they contend, ensure greater benefits to developing countries, which are seen as rich in genetic resources of agricultural crops, despite the greater costs which might be associated with the acquisition (or failure to access) materials needed by the developing countries themselves.

It is tempting, and it is common, to acknowledge no distinction between the historical transfers of crops (and the economic and developmental effects of the transfers) and current germplasm flows and their effects. While aware of historical patterns, this short paper examines the nature and extent of *recent* flows of germplasm, which are more indicative of current needs and interests. By elucidating present relationships and interests, it is hoped that this paper will contribute to more informed and rational policy making in regards to access and benefit-sharing for plant genetic resources for food and agriculture (PGRFA).

An examination of germplasm flows is relevant in the context of current negotiations at the Food and Agriculture Organization of the United Nations (FAO) over the possible establishment of a multilateral system which would govern access to and benefit sharing from plant genetic resources for food and agriculture. It is also timely in regards to ongoing discussions by the Conference of Parties to the Convention on Biological Diversity in regards to access and benefit-sharing.

Policy-makers in the various fora might appropriately ask a number of straightforward questions: Whose interests would be served by a multilateral system facilitating access to genetic resources, and whose, if any, would be served by more restrictions being placed on access by the current holders/owners of this germplasm? Is the flow of germplasm still from developing to developed countries? Do developing countries "contribute" more germplasm than they receive? Would they benefit more by regulating access and trading access for agreed benefits on a sample-by-sample basis? In summary, what can data on current germplasm flows tell us about the advisability of organizing future transfers through either a multilateral system such as that under debate at FAO, or a bilateral system such as might emerge if FAO negotiations fail?

Data for this study was available through SINGER<sup>6</sup> from the International Rice Research Institute (IRRI), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Center for Agricultural Research in the Dry Areas (ICARDA).<sup>7</sup> The International Maize and Wheat Improvement Center (CIMMYT) provided some summary data on genebank transfers,

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<sup>6</sup> SINGER, the System-wide Information Network for Genetic Resources, is the genetic resources information exchange network of the International Agricultural Research Centres of the Consultative Group on International Agricultural Research (CGIAR). It provides access to information on the collections of genetic resources held by the CGIAR Centres. Together, these collections comprise over half a million samples of crop, forage and tree germplasm of major importance for food and agriculture. SINGER can be accessed through the internet at: [www.singer.cgiar.org](http://www.singer.cgiar.org). The authors express their appreciation to the member Centres of the CGIAR System-wide Genetic Resources Programme for their assistance in providing data through SINGER.

<sup>7</sup> For the collections at IRRI, data was available for 1985-1997; for ICARDA, 1990-1997; for ICRISAT, 1974-1997.

newly assembled data on distributions from nurseries, and summary data on CIMMYT contributions to variety releases in the developing world. In addition, data on germplasm exchanges from 1972-1990/1 between fourteen developing countries and the centers of the CGIAR (plus AVRDC) was also available. Thus, in some cases we can look at flows into and out of a selected group of countries over a 19 year period — an approach which can provide some indication of what countries have provided in relation to what they have received from genebanks. And, in other cases, with the available data, we can examine flows to virtually all countries, for a particular crop.

An additional source of information for this study was The State of the World’s Plant Genetic Resources for Food and Agriculture, a volume based on 154 country reports and published by FAO in 1998.

### Sources of Supply of Genetic Resources

Conscious and concerted efforts to collect and conserve genetic resources date at least to the 1920s. By the late 1950s genebanks were established in a number of countries, most notably the United States and the former USSR.<sup>8</sup> The number of accessions<sup>9</sup> conserved in genebanks now exceeds six million, as shown in Table 1. The CGIAR holds over 500,000 accessions “in trust” for the international community under the auspices of FAO.

Table 1. Genebanks and Accessions in *Ex Situ* Collections<sup>10</sup>

<b>Region /Institution</b>	<b>Number of Genebanks</b>	<b>Number of Accessions</b>
Africa	124	353,523
Latin America & Caribbean	227	642,405
North America	101	762,061
Asia	293	1,533,979
Europe	496	1,934,574
Near East	67	327,963
CGIAR	12	593,191
<b>TOTAL</b>	<b>1,320</b>	<b>6,147,696</b>

According to estimates by FAO, a large proportion of the genepool of the major crops has been sampled and placed in collections. Landraces<sup>11</sup> make up a substantially larger portion of CGIAR

<sup>8</sup> Fowler, Cary, and Pat Mooney (1990), *Shattering: Food, Politics and the Loss of Genetic Diversity*. Tucson: University of Arizona Press.

<sup>9</sup> An accession is a distinct sample of seed, plant, or other germplasm material that is maintained as part of an *ex situ* collection. Though the genetic uniqueness of each sample is not always confirmed (nor would it be cost-effective to do so with current technologies), each sample has unique provenance and is catalogued in the collection with its own identifier.

<sup>10</sup> FAO (1998). *The State of the World Plant Genetic Resources for Food and Agriculture*. Rome: FAO.

<sup>11</sup> Landraces are crop populations that are the product of breeding or selection carried out by farmers and their communities, usually over many years.

collections (59%) than they do in governmental (12%) or private (9%) collections. Thus, much of the diversity that can be found in farmers' fields today, and a great amount of diversity that no longer exists on farms, can be accessed through genebanks.

Genebanks do not and cannot contain "all" of the diversity of a crop, since even if all geographical areas and plant types could be sampled, diversity is continually generated by the genetic recombinations in plant breeding programs and evolution in farmers' fields. Still, plant breeders strongly prefer to access materials from genebanks rather than through collecting expeditions. It is easier, quicker, less costly, and the materials generally come with valuable associated information (characterization and evaluation data). Searches for needed genetic diversity will begin with other cultivars and breeding lines, followed, perhaps, by database searches for other modern cultivars and breeding lines. If the desired material cannot be found in other cultivars, then the breeder might turn to *ex situ* collections. If this fails, a collecting expedition might be organized, if it seems likely that the needed material can be found. But given the size of current collections and the lack of documentation about the characteristics of farmers' materials that have not yet been sampled, such expeditions are rare. More often, expeditions are organized for more general purposes such as completing the sampling of a crop in a given region.

Although genetic resources obviously did not originate in genebanks, the main *source* of genetic resources today is *ex situ*, despite the fact that impressive diversity still exists in fields and gardens around the world, where it continues to evolve and to be developed. The genebank has become a modern-day "center of diversity." The principle suppliers of genetic resources are no longer farmers but genebank directors and breeding program managers.

The role of international genebanks is illustrated by the 60 to 1 ratio of germplasm samples distributed by the CGIAR genebanks to developing countries compared to accessions received in 1992. While we consider an accession provided to a CGIAR genebank as "unique" (see footnote 9), multiple samples of the same accession may be requested by several countries simultaneously or any one country successively. This in no way diminishes the value of the accession, since it implies that it is demanded and perhaps utilized in breeding or research more frequently. In other instances accessions need to be replaced due to losses that result from improper storage conditions or other problems. Furthermore, the 60 to 1 ratio is a lower bound estimate of the total number samples provided to end users, since a single sample acquired by one user (say, a national genebank) is transferred subsequently to other users (breeding programs) within the same country.

In recent years, many national and international programs have reduced collecting efforts. According to FAO:

The decrease in international collecting activities has developed in parallel with a general improvement in the conservation infrastructure at the national level. With the development of national plant genetic resources programmes and of national conservation facilities, the collecting of germplasm is now becoming more of a country-

driven process based on national priorities.<sup>12</sup>

Today, wheat genetic resources, for example, are more likely to be acquired from a genebank in the CGIAR System (e.g., CIMMYT) or a national genebank in the U.S. or Russia, than from a country in the original center of origin or diversity. Sweet potato will be obtained from the CGIAR System (e.g., CIP), the U.S. or Japan, holders of the three largest collections. Countries in the Vavilov centers of origin are no longer the principle supplier of such materials. In most cases, they ceased filling this role decades ago.

In addition, while most major agricultural crops were domesticated in developing countries, many developing countries were never a “center of diversity” for any/many important crops. A large number of developing countries (like most developed countries), have had comparatively little to offer historically from either *in situ* or *ex situ* sources.<sup>13</sup> They have been more “importers” than “exporters” of plant genetic resources. As the Brazilian Minister of Agriculture observed to the FAO Conference, Brazil has “a food matrix composed almost entirely of non-native species,” which explains the country’s need for a “mechanism of facilitated access” to plant genetic resources for food and agriculture.<sup>14</sup>

In this section we have seen that a considerable portion of existing crop diversity has been collected and stored in genebanks. Breeders will typically turn to well organized and documented genebank collections before going to the field to search for the same genetic material. The preference for gaining access through existing *ex situ* collections is illustrated by the 60 to 1 ratio of samples distributed by CGIAR genebanks to samples collected by those genebanks during a given period. Whereas farmers’ fields in developing countries were the chief source of materials historically, the genebank plays that role today.

### Germplasm Flows between Selected Countries and International Center Genebanks

In this section we examine the flow of germplasm samples between specific developing countries and the collections of international agricultural research centers over an 18-19 year period. In 1994, the International Fund for Agricultural Research published a series of case studies on the role of international agricultural research centers in particular developing countries. The studies were prepared by Dr. Trevor Williams, the first executive secretary of the International Board for Plant Genetic Resources (later, the International Plant Genetic Resources Institute) at FAO. Each study provided data on germplasm samples exchanged between the centers and the country in question from 1972 to 1990/1. The analysis provided here is based on data from fourteen countries covered by IFAR:

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<sup>12</sup> Ibid.

<sup>13</sup> Many developing countries fall outside of all Vavilov centers. In other cases, countries may be an historical “center” for only one or two crops. CGIAR data indicates that a number of countries have supplied relatively few accessions currently stored in CGIAR genebanks. In other words, not all developing countries are well-endowed in terms of intra-species crop diversity.

<sup>14</sup> Statement of Marcos Vinicius Pratini De Moraes, Minister of Agriculture and Supply, to the 30<sup>th</sup> Session of the FAO Conference, Rome, 1999.

Chile, Colombia, India, Indonesia, Kenya, Madagascar, Pakistan, Peru, Philippines, Rwanda, Saudi Arabia, Syria, Tanzania, and Zimbabwe.

Exchanges were categorized by crop, e.g., cereals, roots and tubers, legumes and pulses, vegetables, and forages. The results are provided in Table 2.

Table 2. Exchanges of Germplasm Samples Between Selected Developing Countries and *Ex Situ* Collections of International Agricultural Research Centers, 1972 – 1990/1<sup>15</sup>

Crop Category	Number of Samples Provided Fourteen Developing Countries to IARCs	Number of Samples Distributed to Fourteen Developing Countries	IARC Variety Releases in Fourteen Developing Countries
Cereals	63,242	247,258	546
Roots & Tubers	17,674	15,302	45
Legumes & Pulses	32,983	201,570	68
Vegetables	2,707	47,444	12
Forages	7,373	16,878	7
TOTAL	123,979	528,452	678

The summary data in Table 2 shows that the fourteen countries surveyed were net recipients of germplasm samples, at a ratio of 4 to 1, during the 18-9 year period. This is significant in several respects. The period 1972-1990/1 is unique in that it was during this period that international efforts were mobilized to collect plant genetic resources. IPGRI (then IBPGR) was founded, collecting expeditions financed, genebanks established, and a system of base collections of major crops put into place. It is during this period that the greatest concentrated *outflow* of genetic resources *from* developing countries took place. Nevertheless, these developing countries still received substantially more germplasm samples from the IARCs than they contributed even during this period of intense collecting.

Total collections of plant genetic resources for food and agriculture (PGRFA) by the CGIAR have been declining since 1987.<sup>16</sup> In 1994, they hovered around 2,000 accessions for all crops, a figure roughly equal to the number of CIMMYT *genebank* distributions of one crop – maize - made to developing countries during the same period. One might expect – and the data provided in the previous section indicates - that with the slowdown in collecting, the ratio of materials received to materials provided might broaden.

The explanation for the data provided above is relatively straightforward. Countries providing their own materials to the system have access not only to their own, but also to those of other countries. It is important to note, therefore, that the fourteen developing countries did not “lose” the 124,000

<sup>15</sup> International Fund for Agricultural Research (1994). “Agriculture in (Name of Country): The Role of International Agricultural Research Centers.” Arlington, Virginia: IFAR.

<sup>16</sup> System-wide Genetic Resources Programme (1996). Report of the Internally Commissioned External Review of the CGIAR Genebank Operations. Rome: IPGRI.

accessions provided to the IARCs. Presumably, they still had access to those accessions, either in their own genebanks or their farmers' fields, or, if needed, from the IARCs themselves. What they gained, however, was access to additional materials provided by other countries. Had access to this material been sought from other countries under a bilateral regime, these fourteen countries would have had to negotiate to "buy" four times as many samples as they themselves had to "sell," a situation which would clearly have put all the countries at a sizeable disadvantage. Moreover, the transaction costs associated with negotiating for access with more than 125 countries (the number represented in IARC collections of these crops) would have been substantial.

A second important observation can be made concerning Table 2. The fourteen developing countries were net recipients of germplasm in all but one of the categories of crops. Negotiations at FAO indicate that countries are willing to establish a multilateral system of facilitated access only for a certain list of crops. Such a list, as presently conceived would omit a large number of vegetable crops, and possibly even forages. The countries surveyed by IFAR received almost *eighteen times* as many samples of vegetables as they provided, and more than *twice* as many accessions of forages. The data indicates a high degree of dependency of developing countries on the existing "open access" system of the IARCs for precisely those crops least likely to be included in a facilitated access agreement in the future. Based on available data, one must conclude that a multilateral system which does not include such materials would create substantial problems of access for developing countries.

The case studies analyzed in this paper show that during a peak period of plant collecting, distributions of germplasm samples to developing countries still far exceeded flows out of developing countries. This pattern held for all crop categories except for roots and tubers, which in this case might be explained by the particular composition of the countries sampled. Interestingly, future access to certain crop categories (eg., vegetables and forages) might be restricted and limited if proposals advanced by some countries (including a number of developing countries) are approved at FAO. Historically, developing countries have been major net recipients of samples transferred. Restrictions may alter this pattern to the disadvantage of developing countries.

### Germplasm Flows of Selected Crops from International Center Genebanks

Not surprisingly, when crop-specific data from CGIAR centers is examined it shows a similar pattern – developing countries are substantial *recipients* of germplasm samples from CGIAR genebanks, and the bulk of germplasm flows are currently *towards* developing countries.

All crops with relevant data in the SINGER database as of March 2000 were analyzed. The resulting list is composed of crops (and in the case of Aegilops, a wild relative) of interest to a broad range of countries. In analyzing transfers to and from countries, countries were initially grouped as low, lower middle, upper middle, and high income according to the World Bank classification system, which is based on gross national product. Three indicators were calculated for each crop and each income group (Figures 1-4): (1) the total number of accessions provided to the genebanks by countries in the group; (2) the total number of samples received by countries in the group from the accessions contributed by

the group and all others; and (3), the total number of samples received by countries in other groups from the accessions contributed by the group. To enable comparisons among figures, the range of the vertical axis has been standardized. Since the underlying data are assembled over different crops and time periods, the data are best considered as projections of transfers for a representative period (1985-1995).

The heights of the bars in Figures 1 through 4 show clearly that while low and lower middle income countries contributed greater numbers of accessions, they also received more germplasm samples than higher income groups. Two points are clear from a comparison of the figures. First, as a group, low income countries have expressed the greatest demand for germplasm samples from accessions held in the collections. For example, the total number of sorghum samples received by these countries is greater than the total number of samples received either by upper middle or high income groups for *all* crops. For some key crops such as chickpea, groundnut, sorghum, and lentils, the numbers of samples received by low income countries as a group during one decade alone represents twice their contribution. This ratio will likely increase in the future with reduced frequency of collection. Second, in most crops, the total number of samples received by both the low and lower middle income groups is greater than the number of samples distributed to other groups from the accessions they contributed. In terms of numbers of samples transferred relative to unique accessions contributed, higher income groups did not gain at the expense of lower income groups. On the contrary, low and lower middle income groups have been *net beneficiaries*.

Once collected and placed in a CGIAR genebank under the terms of their agreements with FAO, materials remain available, in theory, forever. Thus, as argued above, one might expect that the ratio of contributions to receipts would tend to become more favorable to each country and all groups over time as the amount of collecting tapers off.

Table 3. Numbers and percentage distribution of material transfers from CGIAR collections to developed and developing countries, by crop\*

Crop or Species	Genebank collection	Time period*	Developing Countries		Developed Countries		Total Number
			Number	Percent	Number	Percent	
Rice	IRRI	1985-1997	167937	89.8	19078	10.2	187015
Wheat	CIMMYT	1987-1998	30569	76.9	9201	23.1	39770
Maize	CIMMYT	1987-1998	12938	63.0	7602	37.0	20540
Barley	ICARDA	1990-1997	17625	67.1	8623	32.9	26248
Sorghum	ICRISAT	1974-1997	171071	86.7	26240	13.3	197311
Faba	ICARDA	1990-1997	13280	82.8	2750	17.2	16030
Chickpea	ICARDA	1990-1997	16805	89.6	1951	10.4	18756
	ICRISAT	1974-1997	160319	93.6	11047	6.4	171366
Aegilops	ICARDA	1990-1997	13414	88.5	1746	11.5	15160
Groundnuts	ICRISAT	1974-1997	131251	99.0	1275	1.0	132526
Pigeon peas	ICRISAT	1974-1997	61205	97.7	1466	2.3	62671

\* Refers to time period for which data are currently available from CGIAR genebanks.

Source: IRRI, ICARDA, ICRISAT, drawn from SINGER database. CIMMYT data from B.

Skovmand and S. Taba, CIMMYT genebank.

We can also view all countries and transfers in terms of development status. The SINGER data demonstrate that developing countries received the majority of samples of each crop distributed by CGIAR genebanks (Table 3). Over 90% of the transfers of pigeon peas and chickpeas, and close to 100% of the groundnuts, went to developing countries. The percentage was the lowest with maize and barley, nevertheless, over 60% of the samples distributed for each crop went to developing countries. It should be observed that the flows do not need to be overwhelmingly in the direction of developing countries to indicate that developing countries are benefiting. Likewise, the fact that developed countries received only a small percentage of total transfers of groundnuts does not mean that they were hurt by, or failed to benefit from, this allocation of transfers. Furthermore, the SINGER data demonstrate that a large proportion of flows occur within regions and among the developing countries, with the CGIAR centers serving as intermediaries.

Detailed data from the ICRISAT and IRRI genebanks reveals that over the past 25 years, samples sent to commercial companies represented less than 5 percent of all transfers for rice, chickpea, groundnut, and pigeonpea. While sorghum transfers to commercial companies reached 31 percent of transfers in 1991 (in a year of relatively low total transfers), they averaged less than 5 percent annually from 1973 to 1997. Excluding internal transfers, over 90 percent of transfers from ICRISAT collections have been to national programs and universities (Figure 5).

#### Flows of Improved Germplasm from Center Breeding Programs

While transfers of materials from CGIAR genebanks are significant both in terms of volume and value to crop breeding programs, transfers by the centers of breeding lines and other improved materials is substantially larger both numerically and, one might argue, in terms of economic importance. Time lags are of the essence in valuing the economic benefits from breeding activities, and the advanced lines distributed by nurseries are typically bred into varieties and released to farmers more quickly than germplasm samples from genebanks, since these are more likely to be landraces. A few isolated, but highly revealing, examples will suffice to demonstrate the magnitude of nursery transfers from breeding programs. The examples are drawn for rice, wheat, and maize—the world's three major cereals.

From 1994 to 2000, the International Maize and Wheat Improvement Center (CIMMYT) distributed 1.2 million seed samples of bread wheat, durum wheat, triticale, barley and other lines. In 1998-9 alone, the weight of seed shipped was over 11,000 kg. In each year 65-77% of samples were sent to developing countries, with 71.3 percent of the total distributed to developing countries over the six-year period (Figure 6).

The greatest share of these materials was transferred to public cooperators. About a quarter of the recipients of the bread and durum wheat germplasm in the developed world were in the private sector. Though the total transfers to developing countries were much greater for each type of material, less than 10 percent of cooperators receiving the material in developing countries were from the private sector

(Figure 7).

What historical role has this transfer played in international wheat improvement? What contribution does it make to the varieties released by developing countries and sown by their farmers? From 1966 to 1997, 85 percent of all spring bread wheat varieties and 86 percent of all spring durum varieties released in developing countries had CIMMYT ancestry (Figures 8-9).<sup>17</sup> Most of the wheat grown in the developing world is spring habit, and most of the spring habit wheat sown in the fields of developing country farmers is CIMMYT-related.

CIMMYT ancestry does not imply genetic uniformity, however. CIMMYT-related varieties are a vast array of germplasm constituted by genetic recombination of diverse sources of materials from throughout the wheat growing world. A recent summary of scientific findings concludes that genealogical diversity and molecular genetic diversity have increased over time in CIMMYT parents, even while yield potential, yield stability, nitrogen use efficiency, tolerance to heat and drought have improved. This “modern” form of diversity depends very much on exchange of germplasm in a multilateral context.<sup>18</sup>

The most recent global data for maize is currently being assembled and is not yet published. Results for Latin America demonstrate that while the maize seed industry is increasingly dominated by private companies, both public and private maize breeders have made extensive use of CIMMYT materials. From 1966 to 1997, approximately 55% of all varieties and hybrids released by public breeding programs in Latin America contained CIMMYT germplasm. An estimated 75% of all seed sold by private companies in Latin American in 1996 contained CIMMYT-derived germplasm. Public-sector breeders now tend to subject CIMMYT materials to additional cycles of selection before using them to form finished cultivars. Private companies use CIMMYT seed in different ways, depending on their size and structure.<sup>19</sup> Thus far, more than a thousand maize trials have been requested from CIMMYT this year, compared to 658 in 1999 and 188 in 1998. Each trial may contain from 50 to as many as 500 distinct lines. Moreover, CIMMYT projects that it will produce more than 500 new varieties for testing and use by developing country national programs in the next 2-3 years.

In 1999, the International Rice Research Institute (IRRI), sent out 24,831 samples of IRRI-developed materials directly to 46 countries, and another 4,600 through the International Network for Genetic Evaluation of Rice (INGER).<sup>20</sup> INGER provided a total of 18,533 samples in 1999 (70% originating from national agricultural research programs). Countries participating in INGER gain access to materials from other countries, and in some cases, they have been able to import them directly from the INGER

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<sup>17</sup> P. W. Heisey, M. Lantican, and H.J. Dubin. 1999. Assessing the Benefits of International Wheat Breeding Research: An Overview of the Global Wheat Impacts Study. Part 2 of the *1998-9 World Wheat Facts and Trends*. Mexico, D.F.: CIMMYT.

<sup>18</sup> M. Smale, M. Reynolds, M. Warburton, B. Skovmand, R. Trethowan, R. Singh, I. Ortiz-Monasterio, J. Crossa, M. Khairallah, and I. Almanza. forthcoming. *Dimensions of Diversity in CIMMYT Bread Wheat from 1965 to 2000*. Mexico, D.F., CIMMYT.

<sup>19</sup> M.L. Morris and M. A. López-Pereira. *1999 Impacts of maize Breeding Research in Latin America, 1966-1997*. Mexico, D.F.: CIMMYT.

<sup>20</sup> Personal Communication with Edwin Javier, INGER Coordinator, Genetic Resources Center, IRRI.

nurseries. Evenson and Gollin (1997)<sup>21</sup> have estimated that ending the INGER program would reduce the number of rice varieties released by 20 varieties per year, entailing an economic loss of \$1.9 billion.

A bilateral system for access and benefit sharing for PGRFA would imply that each country would be responsible for regulating access, conserving indigenous materials, and improving germplasm for use by farmers. CGIAR programs, dependent as they are on the easy exchange of genetic materials and the provision of research funds by donors, might appear out of place or unimportant in such a context, an appearance which would threaten funding and threaten the continued production of public goods by the centers.

### Restoration of Germplasm to National Programs

According to FAO:

The incidence of disasters caused by war, civil strife, drought, flood, and fire has increased in the past decades and is at record levels in the 1990s. Such calamities have profound effects on agricultural systems, involving farmer seed systems as well as the social structures which bind communities together....During disasters, countries and communities are often caught off-guard, and they frequently lack the capacity to restore their seed supply systems, often leading to long-lasting seed and food insecurity.<sup>22</sup>

Sustainable agriculture requires - at the very least - seeds and planting materials adapted to the natural environment (and ideally, to the cultural and economic "environment" as well). In times of crisis, the loss of adapted seed and genetic resources can pose a serious threat to countries.<sup>23</sup> Accessions or entire collections can be lost through accidents or mis-management even in "normal" times. In such situations, restricted-access systems are ill-equipped to meet the needs of effected countries. The use of international collections to restore germplasm, like the provision of improved materials, is seldom fully appreciated in discussions of germplasm transfers, or the benefits of multilateralism. The scale of

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<sup>21</sup> Evenson, R. E. and D. Gollin. 1997. Genetic resources, international organizations, and improvement in rice varieties. *Economic Development and Cultural Change* 45 (3): 471-500.

<sup>22</sup>FAO (1998). Restoring Farmers' Seed Systems in Disaster Situations: Proceedings of the International Workshop on Developing Institutional Agreements and Capacity to Assist Farmers in Disaster Situations to Restore Agricultural Systems and Seed Security Activities. Rome: FAO.

<sup>23</sup> Fowler, Cary (2000). Prospects for Restoring Agricultural System in the Aftermath of Disasters: The Case for Seed. Aas: Agricultural University of Norway.

restoration activities, however, is substantial.

Between 1981 and 1995, CGIAR centers restored germplasm to 38 countries<sup>24</sup>:

- Argentina
- Bolivia
- Botswana
- Brazil
- Cambodia
- Cameroon
- Chile
- Dominican Rep.
- Ecuador
- Eritrea
- Ethiopia
- Gambia
- Guatemala
- Guinea
- Guinea-Bissau
- Honduras
- India
- Iran
- Kenya
- Liberia
- Mali
- Mexico
- Myanmar
- Nepal
- Nigeria
- Pakistan
- Panama
- Paraguay
- Peru
- Philippines
- Rwanda
- Senegal
- Sri Lanka
- Sudan
- Tanzania
- Turkey
- Uruguay
- Zambia

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<sup>24</sup> Op.Cit., System-wide Genetic Resources Programme (1996).

Since 1995, there have been efforts to restore germplasm and planting materials in at least two additional countries: Mozambique and Somalia. The quantity of materials supplied to each country is not known.

Restoration of germplasm following accidental loss, or in the wake of natural disasters and civil strife, is more common than most people realize. Restoration to a particular country depends on samples being stored outside that country. In constructing access regimes, countries may want to consider the effect that restrictions will have on the ability of other countries or the international community to restore germplasm in disaster situations.

### Summary and Conclusions

The data presented and analyzed in this paper covers a period of over 20 years. It was a period of intense plant collecting in developing countries, one in which transfers from developing countries were probably at a never-to-be-repeated high. Nevertheless, transfers to developing countries were considerably larger. The findings of this study of the period can be summarized as follows:

1. Developing countries have been and continue to be recipients of a large amount of germplasm samples from IARCs, receiving more in numbers of germplasm samples from IARC genebanks than they contributed.
2. Developing countries receive significantly more germplasm samples from IARC genebanks than developed countries.
3. Large numbers of improved germplasm samples also flow in nurseries sent by IARC breeding programs to developing countries. The provision of this material is also skewed in favor of developing countries, if compared to developed countries.
4. Distributions of germplasm from IARC genebanks and nurseries to private companies appear minor for the crops included here.
5. The number of accessions added to *ex situ* collections annually by CGIAR centers is small and decreasing. It is insignificant in comparison with the quantity of germplasm samples being distributed from genebanks and breeding programs.
6. Material provided to CGIAR centers is not “lost.” A duplicate is typically deposited by the collector in the source country’s conservation system. It may also continue to be kept and used within the farming communities of the source country.
7. Restoration of germplasm following accidents, natural disasters, war and civil strife, has assisted a large number of countries recover material earlier provided to the IARCs. No precise data is available regarding the number of materials provided in these circumstances.

Individual countries, whether developed or developing, can expect to be net recipients of all categories or crops, and virtually every particular crop, under a multilateral system of facilitated access. This is already the case today. If the current ratio of inflow to outflow of germplasm samples remains as is, but access is subject to restrictions or “bilateralized,” virtually all countries will be required to obtain substantially more materials from others than they themselves have to offer. If such transfers become

monetary-based, all developing countries stand to lose.

While developing countries have provided the biological basis for agriculture in developed countries, they have also provided this basis for each other. All countries and all regions are highly interdependent. Each and every region of the world is very dependent on non-native crops. Charges of “biopiracy” may have some historical interest. They may even be valid in isolated, albeit well-publicized circumstances now. But today, the dominant flow of germplasm is not from “south” to “north.” It is first and foremost a flow of improved germplasm to developing countries, and secondly a flow of genebank materials to developing countries. In terms of the quantity of materials being transferred, modern-day germplasm flows are not associated positively with historic centers of diversity. Instead, the numbers seem to indicate that we are in a period of reverse flows – materials (both farmer varieties and improved materials) are flowing *into* the historic centers of diversity from genebanks and breeding programs.

While it is quite true that developing countries “contributed” much of this material originally, it is also true that developing countries do not access the material as a group. Access is sought by *individual* countries. When individual countries are analyzed, it is evident that an open system of access will provide the individual country with access to more materials than that country could possibly provide to the system. Such access is an important – indeed necessary – condition for future crop improvement in developing countries. The data presented in this paper gives an indication of the extent to which developing countries receive germplasm. It indicates the importance of maintaining genetic resources in the public domain, available to all without undue restrictions, including those that might be imposed by certain intellectual property rights.

Current patterns of germplasm movement do not so much indicate “biopiracy” as they indicate “bioinvestments” being made by developing countries. These investments are reaping tangible dividends in the form of access to additional germplasm, insurance against loss of indigenous germplasm, and procurement of improved materials.

A facilitated access regime, such as that being negotiated at FAO, need not confine the “benefits” to be generated or derived to that of access. Indeed, it should be observed that “access” is not easily paired with “benefit sharing” in international negotiations on PGRFA, precisely because all countries get access to more than they provide, and thus a marketplace situation does not actually exist. Were “benefits” to become linked with “access” in a transaction-based system, all countries could expect to have to provide more benefits than they would receive. Based on the data provided in this paper, one can argue that facilitated access in today’s world is a “win-win” situation for all, and a particularly important need for developing countries. The construction of a truly global system for genetic resources, with facilitated access and secured benefit-sharing, including implementation of the FAO Global Plan of Action, would work to the advantage of all countries.



This study is the first product of a larger effort to examine the magnitude and patterns of current flows of crop germplasm between countries. Research is being conducted largely by the International Plant Genetic Resources Institute (IPGRI) under the auspices of and with the assistance of the Global Forum on Agricultural Research (GFAR).

Ten national genebanks and two regional facilities have been asked to supply data on their acquisition and distribution of germplasm. Other institutions are also welcomed to participate. Please contact IPGRI or GFAR if you are willing to provide data and have it included as part of the larger study.

We hope that this initiative will help inform the current debates and negotiations over the status of plant genetic resources for food and agriculture and over the rules to be established regarding their exchange. The comprehensive study, to be published later this year, should provide a reasonably complete picture of present transfers of genetic resources, elucidating who is providing the material, and who is receiving and using it. This information should help countries assess their dependence on acquired germplasm as well as evaluate the extent to which they supply materials to others, and thus form the basis for more rational policy-making concerning plant genetic resources.

Our initial study focus on transfers of germplasm between developing countries and CGIAR centers. The authors wish to express their appreciation to the System-wide Genetic Resources Programme (SGRP) of the CGIAR for providing and helping interpret data. In particular, we would like to thank Alicia Mercado (CIMMYT), Bent Skovmand (CIMMYT), Paul Heisey (previously CIMMYT, now USDA), Mike Jackson (IRRI), Paula Bramel (ICRISAT) and Jan Valkoun (ICARDA) for their generous assistance.

Figure 1. Germplasm transfers to and from low income countries, for selected CGIAR genebanks, 1985-1995

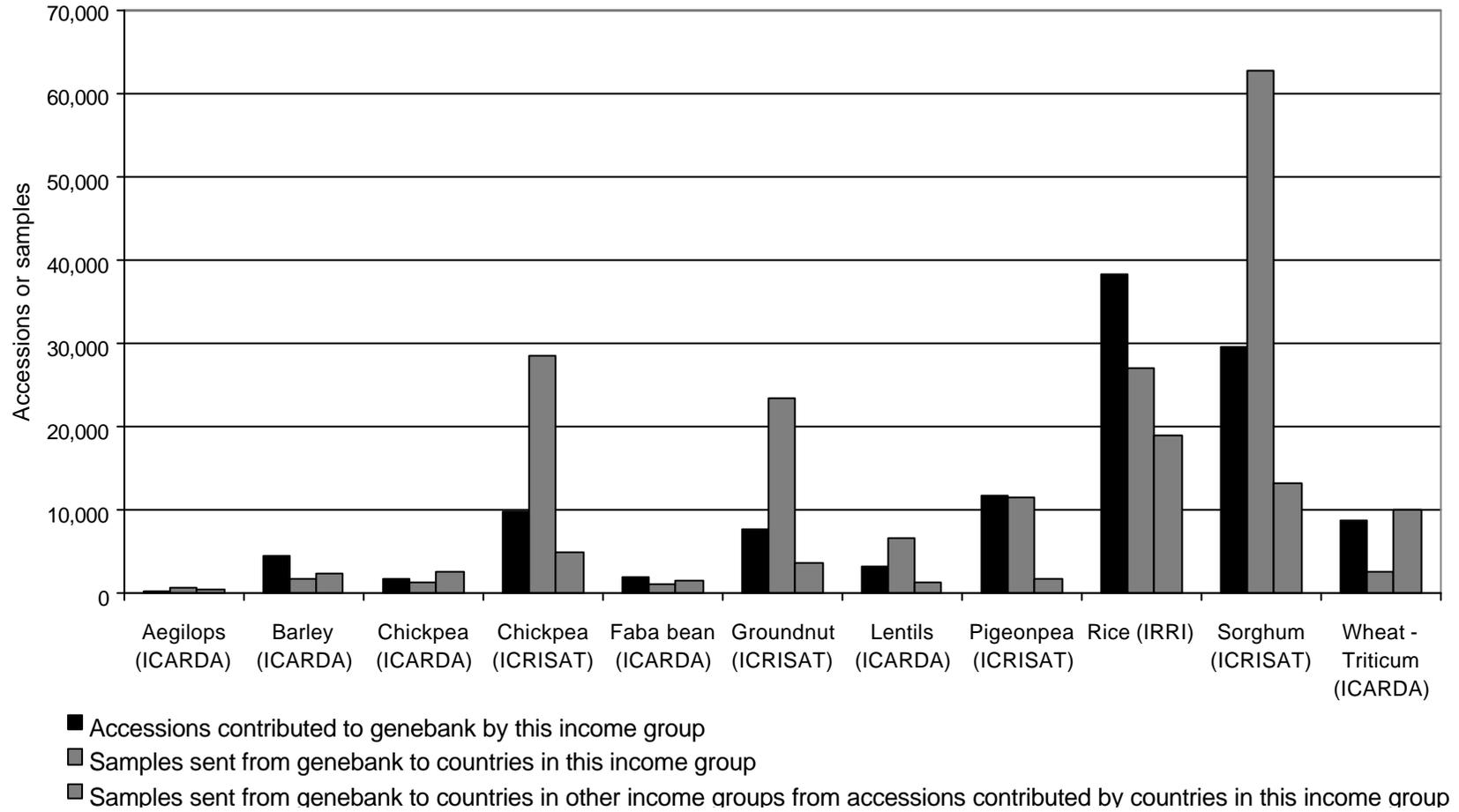


Figure 2. Germplasm transfers of germplasm to and from lower middle income countries, for selected CGIAR genebanks, 1985-1995

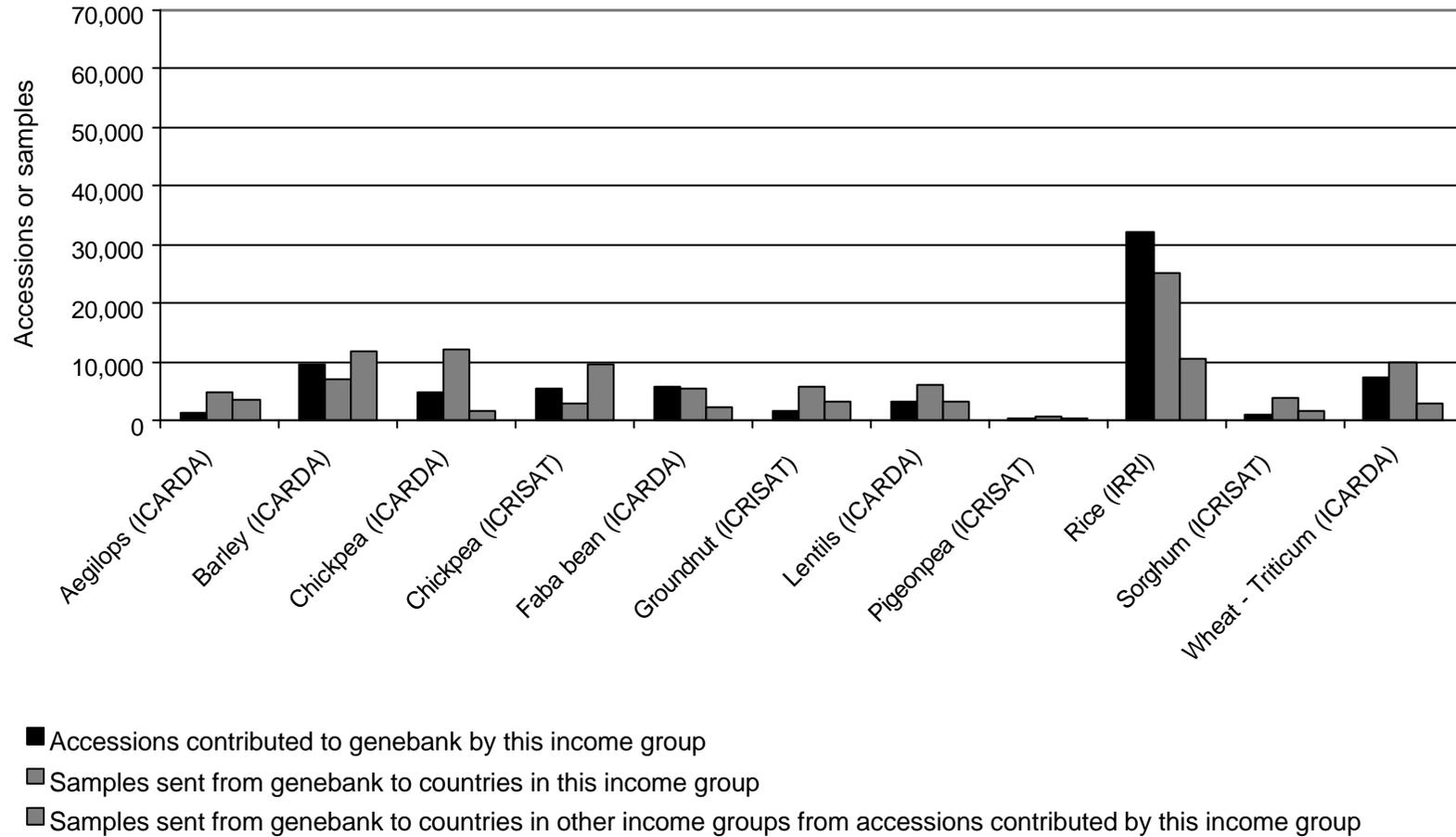
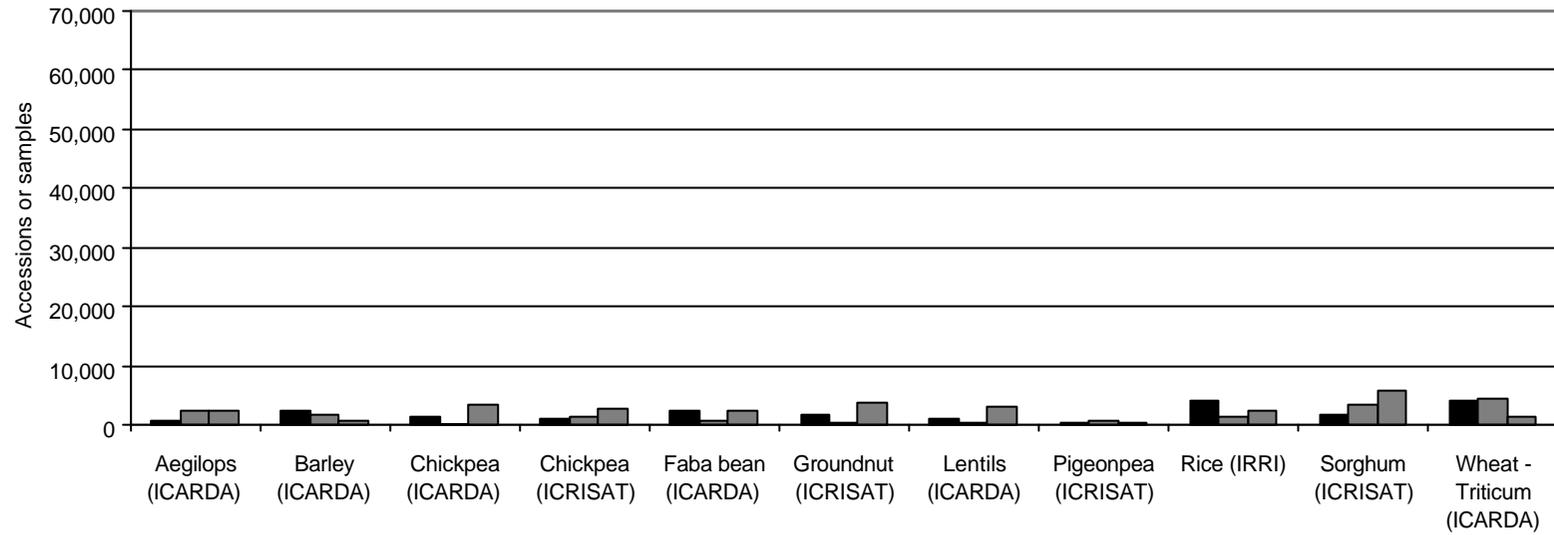


Figure 3. Germplasm transfers to and from upper middle income countries, for selected CGIAR genebanks, 1985-1995



- Accessions contributed to genebank by this income group
- Samples sent from genebank to countries in this income group
- Samples sent from genebank to countries in other income groups from accessions contributed by countries in this income group

Figure 4. Germplasm transfers to and from high income countries, selected CGIAR genebanks, 1985-1995

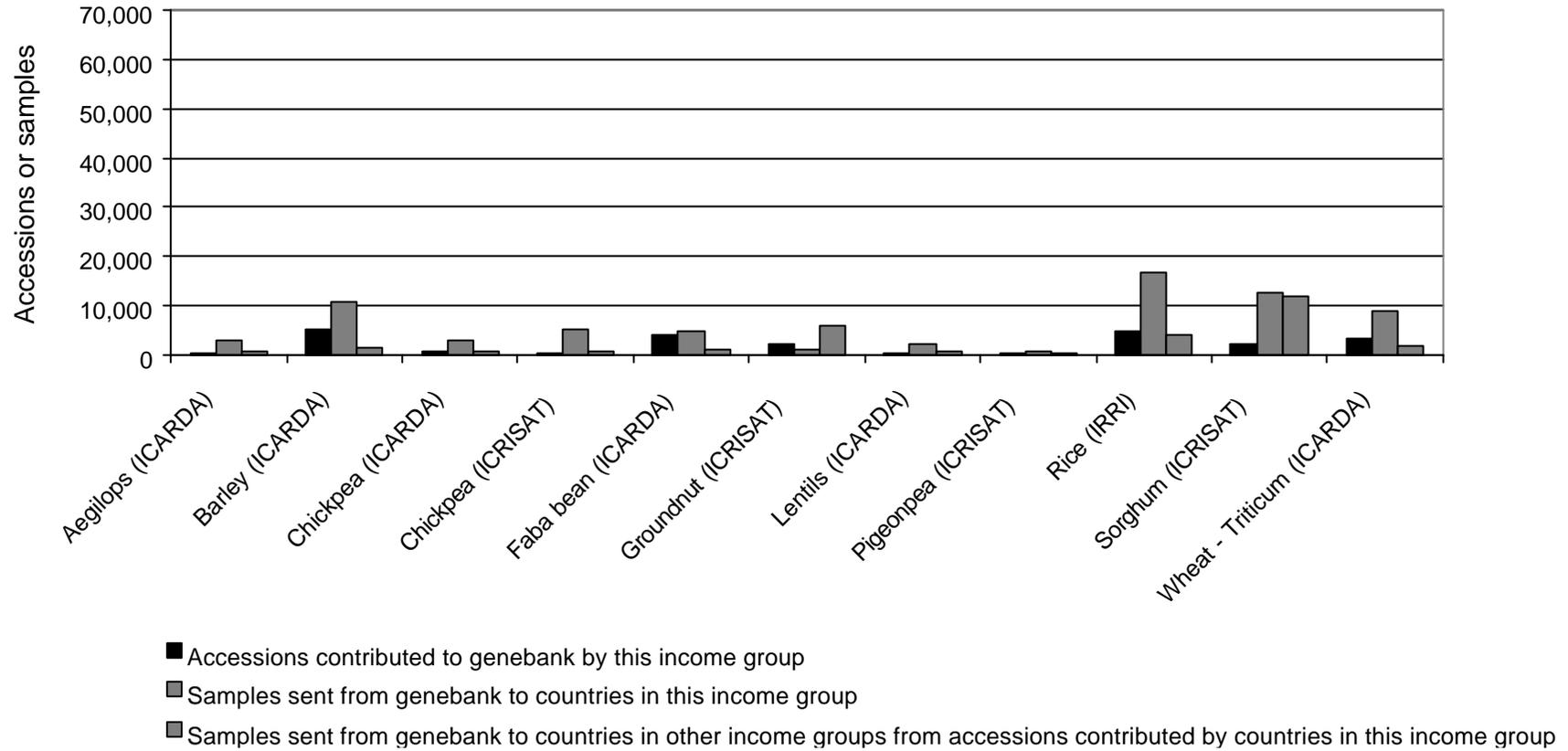
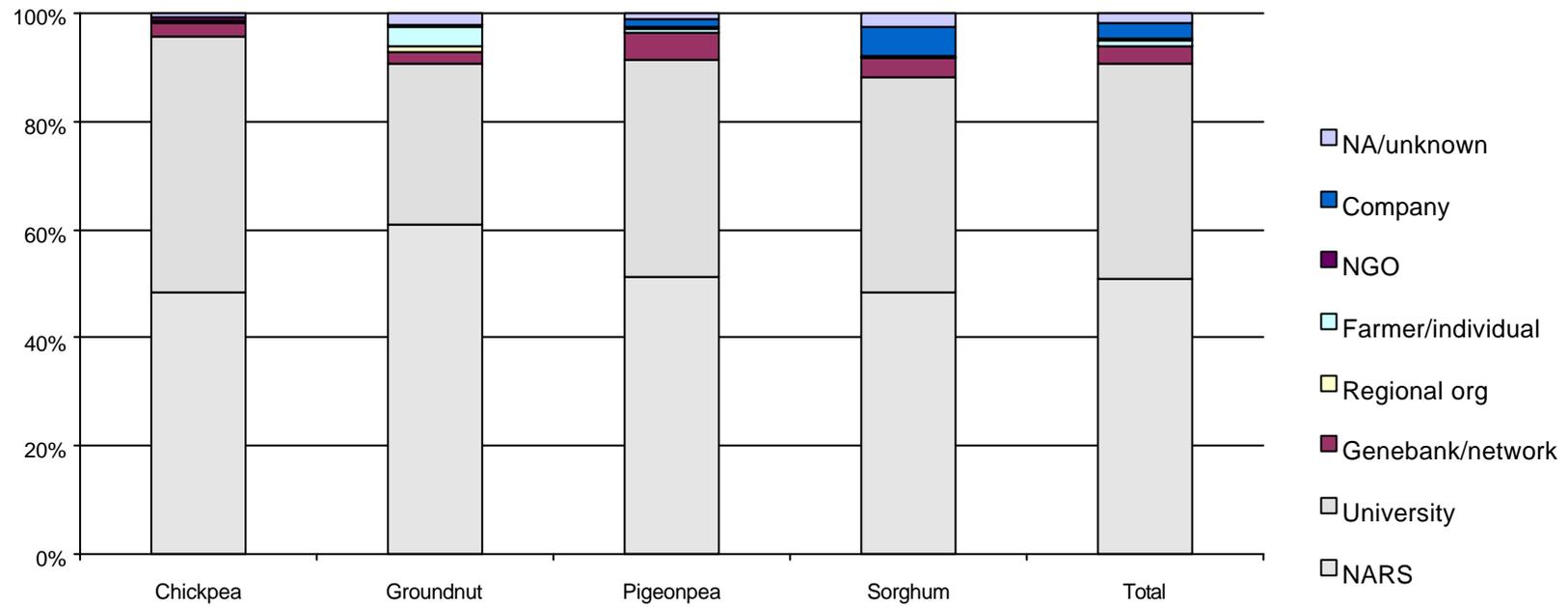
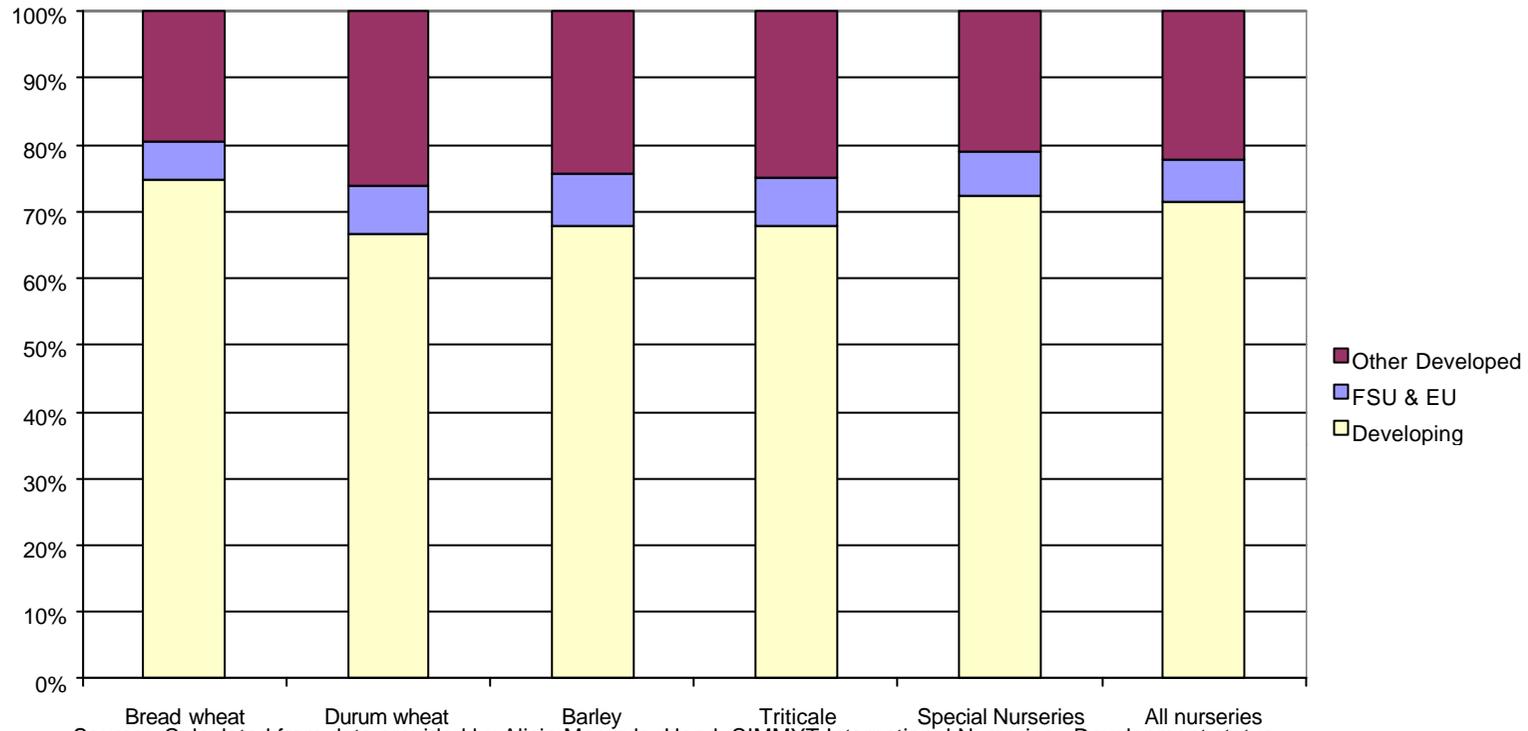


Figure 5. Percentage distribution of materials from ICRISAT collections, by user and crop, 1973-1997



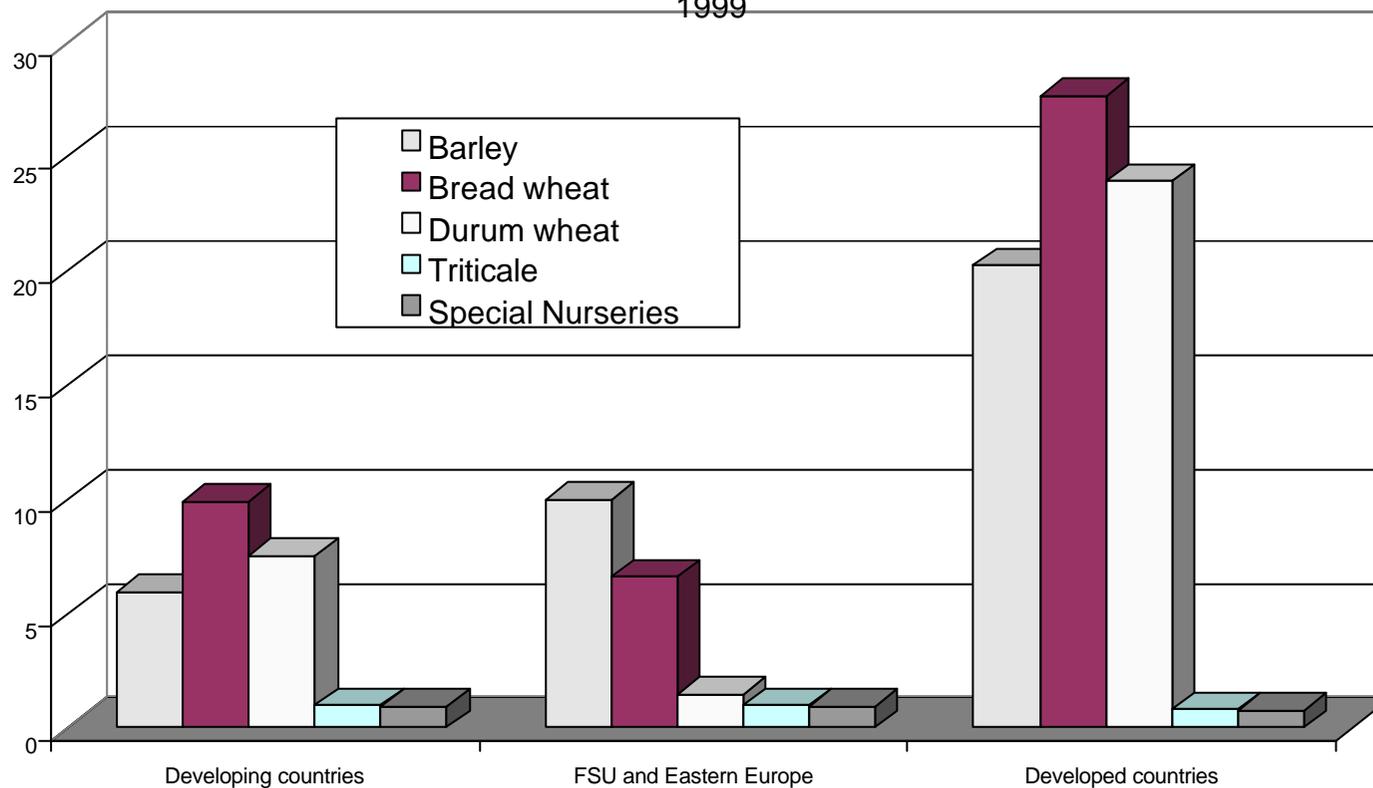
Source: ICRISAT data in SINGER database, SGRP.

Figure 6. Percent distribution of lines sent by CIMMYT International Nurseries to developed and developing countries, 1994-1999



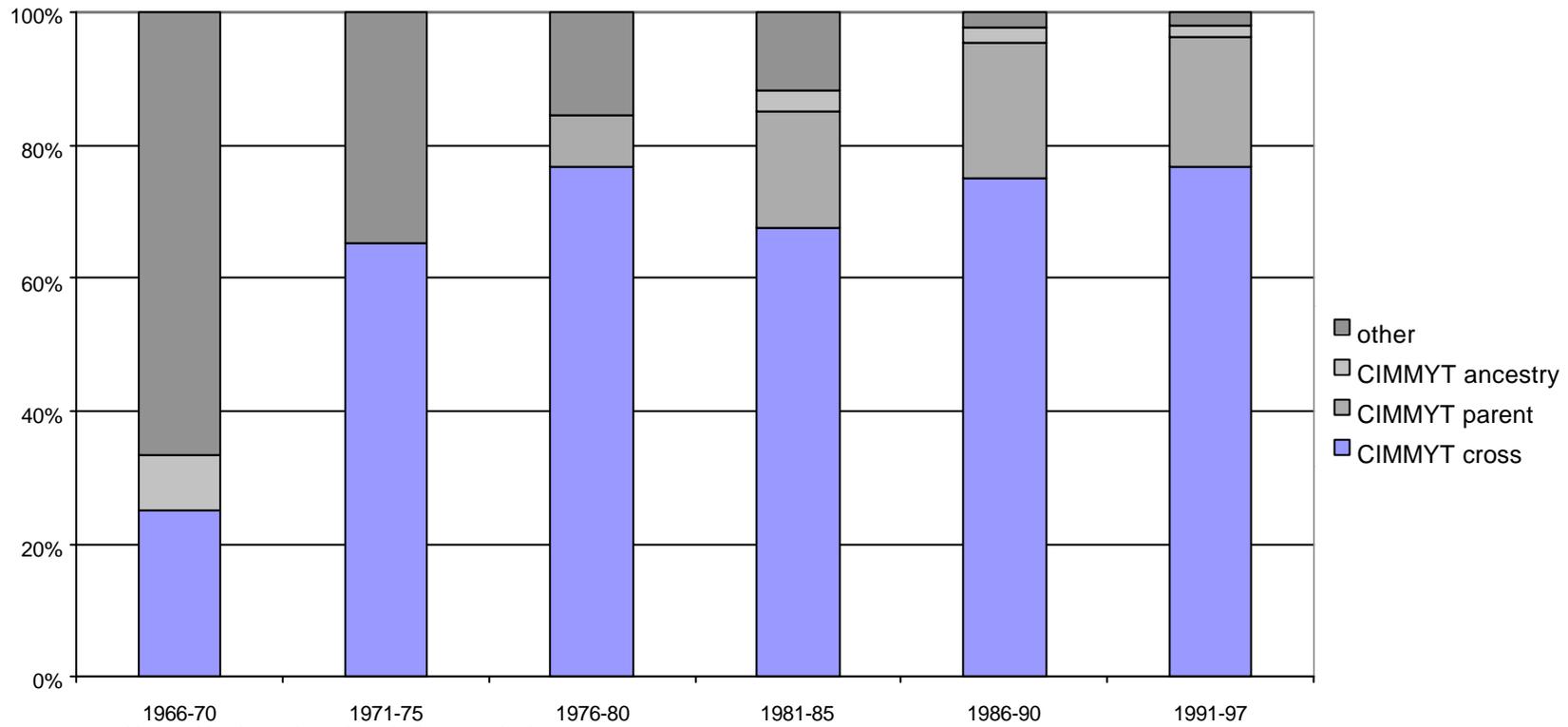
Source: Calculated from data provided by Alicia Mercado, Head, CIMMYT International Nurseries. Development status follows FAO classification. Represents the total number of all seed samples sent for each species in all nursery sets.

Figure 7. Private cooperators as percent of all cooperators receiving lines from CIMMYT International Nurseries, by crop, developing and developed countries, 1994-1999



Source: Calculated from data provided by Alicia Mercado, Head, CIMMYT International Nurseries. Note that a single cooperator may be an institution responsible for dissemination materials to many individual breeders.

Figure 8. Spring durum wheat releases by time period, developing world

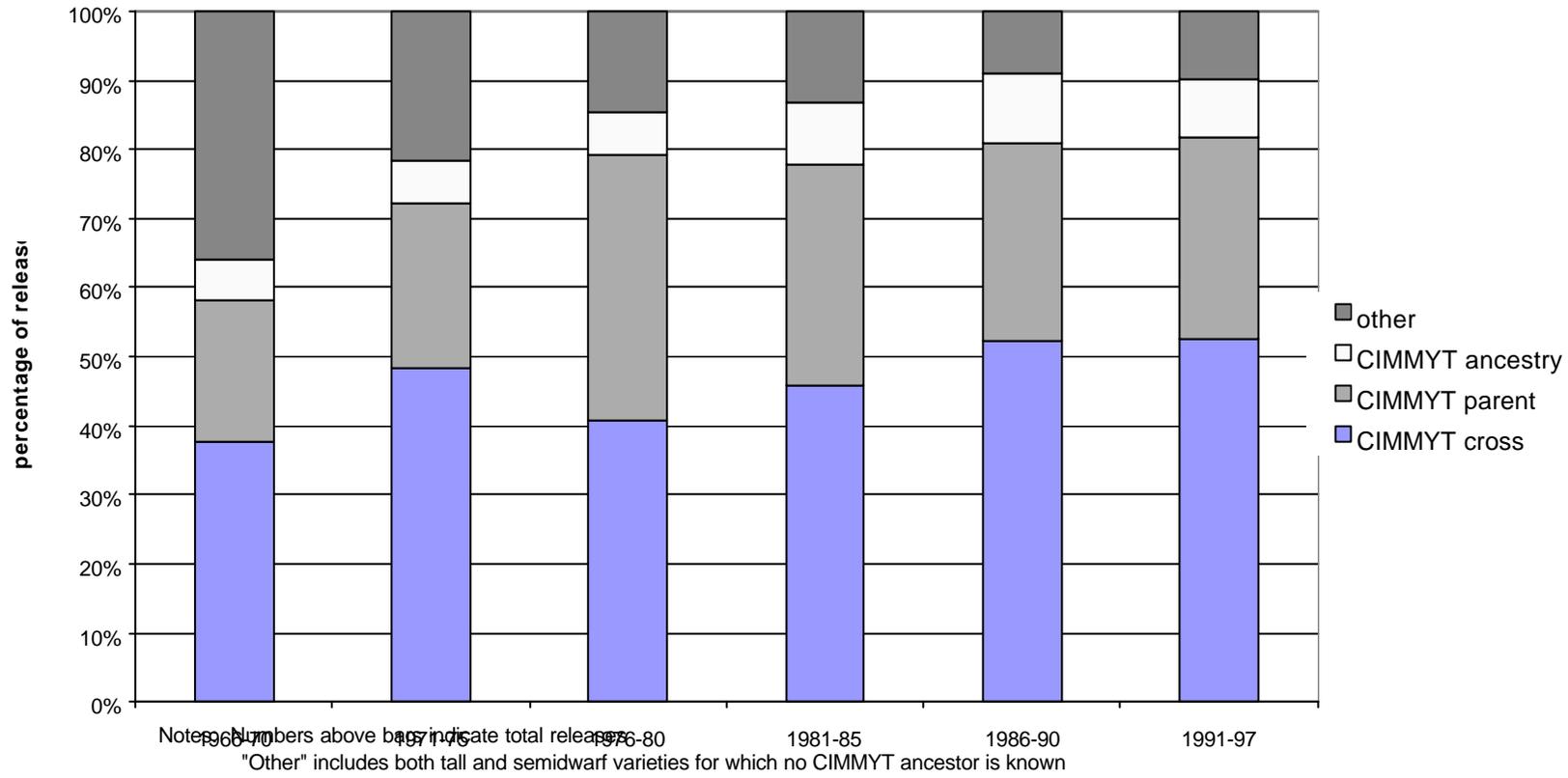


Notes: Numbers above bars indicate total releases

"Other" includes both tall and semidwarf varieties for which no CIMMYT ancestor is known

Source: Heisey, Lantican, and Dubin, 1999.

Figure 9. Spring bread wheat releases by time period, developing world



Source: Heisey, Lantican and Dubin, 1999.