Use of CIMMYT Germplasm

To what extent do maize breeders in Latin America make use of CIMMYT germplasm? Since the main product of the CIMMYT Maize Program is improved germplasm, one obvious way to measure the impact of CIMMYT's maize breeding efforts is to determine the extent to which CIMMYT germplasm is present in cultivars developed by public and private breeding programs throughout the region.

Unfortunately, because of the way modern maize breeding is carried out, it is not always easy to document the use of CIMMYT germplasm. At least three factors make it difficult to identify and track the use of improved germplasm in maize:

1. Many improved OPVs and most modern hybrids have closed pedigrees, meaning that information about their genetic backgrounds is not publicly available. Breeding programs, especially commercial programs that respond to economic incentives, have a clear incentive to keep pedigrees closed, because once the genetic background of an improved OPV or hybrid becomes public knowledge, other breeders will quickly be able to produce the same OPV or hybrid.

2. Maize breeding strategies vary widely, and individual breeders use a range of techniques, most of which involve multiple cycles of selfing, crossing, and/or backcrossing. Selection strategies vary widely and frequently change. Because of the complex and frequently *ad hoc* nature of maize breeding, the precise genetic histories of many improved OPVs and hybrids cannot be known with complete certainty.

3. Even when the genetic history of a particular OPV or hybrid is known, it is not always clear how credit for the breeding effort should be attributed. Modern maize breeding is truly international, and most breeders routinely work with a wide range of source materials obtained from all over the world. Also, the breeding process requires a great deal of teamwork, because promising experimental materials must be evaluated in many different locations, which requires the participation of collaborators. Thus it can be difficult to assign credit to a particular breeder or breeding program.

Notwithstanding these complicating factors, an attempt was made to document the use of CIMMYT germplasm by public and private breeding programs.[4] Since many of the survey respondents were unwilling to provide complete pedigrees for their commercial cultivars,

4 In this context, "CIMMYT germplasm" is defined as germplasm that has undergone at least three cycles of selection at the hands of CIMMYT breeders and has been distributed as a CIMMYT population, pool, inbred line, experimental variety, or experimental hybrid.

information about the use of CIMMYT germplasm had to be requested in fairly general terms. For each improved OPV and hybrid listed in the two varietal databases, the following questions were posed (possible responses appear in italics):

- Does this OPV or hybrid contain CIMMYT germplasm? *(yes* or *no)*

- If the OPV or hybrid contains CIMMYT germplasm, what was the name of the CIMMYT population, pool, or inbred line that was used?

  Name of first CIMMYT population, pool, or inbred line: _____
  Name of second CIMMYT population, pool, or inbred line: _____
  Name of third CIMMYT population, pool, or inbred line: _____

- How was the CIMMYT germplasm used?

Population, pool, or experimental variety used as follows:
Class 2 = basic germplasm (substantial improvement done after received from CIMMYT)
Class 3 = selection from CIMMYT variety trials, with some improvement for local adaptation
Class 4 = direct use of CIMMYT material, no additional improvement performed

Inbred line or hybrid used as follows:
Class 2 = pedigree program (substantial improvement done after received from CIMMYT)
Class 3 = direct use of one or more CIMMYT inbred lines in the formation of the hybrid
Class 4 = direct use of a CIMMYT hybrid (all the inbred lines came from CIMMYT)

Most of the respondents representing public breeding programs were willing to provide this information about the genetic background of public-sector varietal releases. Thus, it was possible to classify almost all public-sector releases according to the amount of CIMMYT germplasm in their backgrounds.

With private-sector (proprietary) cultivars, however, the situation was different. Many private seed company representatives were willing to disclose whether or not CIMMYT germplasm had been used in developing a particular commercial cultivar, and, in cases in which CIMMYT germplasm had been used, they were also willing to indicate how it had been used. In these cases, it was possible to characterize each cultivar as belonging to Class 2, Class 3, or Class 4. Other seed company representatives, however, were reluctant to provide detailed information about the genetic background of specific materials and were prepared to indicate only in very general terms whether or not CIMMYT germplasm had been used in developing a particular cultivar or set of cultivars.

Because of the reluctance of some seed company representatives to provide detailed pedigree information, about one-half of the proprietary cultivars thought to contain CIMMYT germplasm could not be assigned with confidence into Class 2, Class 3, or Class 4. Therefore, proprietary materials were divided into three main categories:

1. definitely do not contain CIMMYT germplasm;

2. definitely contain CIMMYT germplasm (this category was further subdivided into Class 2, Class 3, or Class 4); and

3. probably contain CIMMYT germplasm (conservatively assumed to be Class 2).

Many of the seed company representatives interviewed during the survey stated that even general information about the genetic background of commercial hybrids might be of value to rival companies. Therefore, they agreed to answer questions about the use of CIMMYT germplasm only on the condition that the information not be publicized. For this reason, information on the genetic background of specific cultivars does not appear in this (or any other) CIMMYT publication.

Public breeding programs

Data on the use of CIMMYT germplasm by public maize breeding programs in Latin America appear in Table 20. Use of CIMMYT germplasm is expressed in terms of the percentage of all public-sector varietal releases that were identified as containing some CIMMYT material in their genetic background. Over one-half (55%) of all improved OPVs and hybrids released by public breeding programs during 1966-97 were identified as containing CIMMYT germplasm, reflecting the extensive reliance of national maize breeding programs on CIMMYT materials.

Although CIMMYT germplasm has been popular throughout Latin America, the frequency of its use has varied by sub-region (Table 21). Public breeding programs in Central America have been particularly heavy users of CIMMYT breeding materials. CIMMYT germplasm was present in over 87% of all public varieties and hybrids

Table 20. Use of CIMMYT germplasm by public maize breeding programs, Latin America, 1966-97 (% of cultivars released containing CIMMYT germplasm)

		By ecological adaptation:			
	All public releases	Lowland tropical	Subtropical/ mid-altitude	Highland	Temperate
Central America	**87.4**	**94**	**44**	**–**	**–**
Costa Rica	100.0	100	31	–	–
El Salvador	100.0	100	–	–	–
Guatemala	76.9	100	–	–	–
Honduras	100.0	100	–	–	–
Nicaragua	81.0	79	100	–	–
Panama	78.6	79	–	–	–
Caribbean	**66.7**	**70**	**0**	**–**	**–**
Cuba	66.7	67	–	–	–
Dominican Republic	83.3	83	–	–	–
Haiti	50.0	60	0	–	–
Mexico	**33.3**	**52**	**18**	**10**	**–**
Central America, Caribbean, and Mexico	**53.2**	**74**	**22**	**10**	**–**
Andean Zone	**57.0**	**66**	**46**	**39**	**–**
Bolivia	72.9	77	62	50	–
Colombia	26.1	41	13	0	–
Ecuador	52.0	80	31	50	–
Peru	56.7	60	0	60	–
Venezuela	75.7	76	–	–	–
Southern Cone	**56.2**	**70**	**–**	**–**	**30**
Argentina	40.9	100	–	–	30
Brazil	67.3	67	–	–	–
Chile	–	–	–	–	–
Paraguay	62.5	63	–	–	–
Uruguay	–	–	–	–	–
South America	**56.7**	**68**	**46**	**39**	**30**
Latin America	**54.8**	**71**	**27**	**29**	**30**

Source: CIMMYT maize impacts survey.

Table 21. Approximate CIMMYT germplasm content of publicly developed maize cultivars, Latin America, 1966–97 (% of cultivars released)

	Proportion of source germplasm originating from CIMMYT:			
	0%	1-33%	34-66%	67-100%
Central America	**12.6**	**0.0**	**9.4**	**78.0**
Costa Rica	0.0	0.0	27.8	72.2
El Salvador	0.0	0.0	20.0	80.0
Guatemala	23.1	0.0	10.3	66.7
Honduras	0.0	0.0	0.0	100.0
Nicaragua	19.0	0.0	0.0	81.0
Panama	21.4	0.0	0.0	78.6
Caribbean	**33.3**	**0.0**	**0.0**	**66.7**
Cuba	33.3	0.0	0.0	66.7
Dominican Republic	16.7	0.0	0.0	83.3
Haiti	50.0	0.0	0.0	50.0
Mexico	**67.6**	**5.0**	**13.5**	**14.0**
Central America, Caribbean, and Mexico	**46.8**	**3.0**	**11.4**	**38.9**
Andean Zone	**43.4**	**6.6**	**11.2**	**38.8**
Bolivia	27.1	6.8	10.2	55.9
Colombia	73.9	0.0	6.5	19.6
Ecuador	48.0	20.0	16.0	16.0
Peru	45.5	9.1	18.2	27.3
Venezuela	24.2	3.0	9.1	63.6
Southern Cone	**53.2**	**15.6**	**27.0**	**4.3**
Argentina	71.2	16.4	11.0	1.4
Brazil	32.7	0.0	57.7	9.6
Chile	–	–	–	–
Paraguay	37.5	62.5	0.0	0.0
Uruguay	–	–	–	–
South America	**47.5**	**10.4**	**17.8**	**24.3**
Latin America	**47.1**	**6.5**	**14.4**	**32.0**

Source: CIMMYT maize impacts survey.

released in Central America between 1966 and 1997, and in Costa Rica, El Salvador, and Honduras 100% of the public-sector releases contained CIMMYT germplasm. CIMMYT materials were used less extensively in South America, although the level of use was still very high; in both the Andean Zone and the Southern Cone sub-regions, over 56% of all public varieties and hybrids released between 1966 and 1997 contained CIMMYT germplasm. Ironically, the Latin American country in which CIMMYT materials have been used least is Mexico, where only 33% of public-sector releases have contained CIMMYT germplasm. The relatively low level of use of CIMMYT germplasm within Mexico appears to be attributable to two factors. First, the Mexican national program has direct access to many of the same source materials from which CIMMYT's main lowland tropical populations were developed; Mexican breeders thus have had little cause to rely on CIMMYT's lowland tropical germplasm. Second, many of the varieties and hybrids released by the Mexican national program have been targeted at highland environments; because the importance of these environments is limited outside Mexico, they did not receive explicit attention from CIMMYT until 1985.

As expected, CIMMYT germplasm has been used most extensively to develop cultivars adapted to lowland tropical environments. During 1966-97, CIMMYT germplasm was present in over 70% of all public-sector releases showing adaptation to lowland tropical environments. CIMMYT germplasm was present much less frequently among public-sector releases showing adaptation to subtropical/mid-altitude environments (27%), highland environments (29%), and temperate environments (30%).[5]

The extensive use of CIMMYT's lowland tropical materials by national breeding programs can be attributed in large part to the popularity of several highly successful lowland tropical materials. Noteworthy among these is CIMMYT Population 21 (Tuxpeño), a short-statured, intermediate-maturing, white dent material developed from a Mexican landrace. Population 21 was present in at least 90 different varieties and hybrids released by national breeding programs throughout Latin America, a record that is surely unequaled in the developing world (Table 22). Other widely used lowland tropical materials that are direct or indirect products of CIMMYT's maize breeding program include CIMMYT Population 32 (ETO Blanco),

Table 22. Use of popular CIMMYT materials in cultivars developed by public maize breeding programs, Latin America, 1966-97

	Number of public MVs containing:			
	Population 21 (Tuxpeño)	Population 32 (ETO)	Population 43 (La Posta)	Suwan-1
Central America	**35**	**17**	**15**	**21**
Costa Rica	3	4	5	3
El Salvador	6	0	1	5
Guatemala	15	5	3	5
Honduras	8	3	5	4
Nicaragua	3	0	1	4
Panama	0	5	0	0
Caribbean	**0**	**7**	**0**	**0**
Cuba	0	2	0	0
Dominican Republic	0	4	0	0
Haiti	0	1	0	0
Mexico	**16**	**0**	**0**	**14**
Central America, Caribbean, and Mexico	**51**	**24**	**15**	**35**
Andean Zone	**26**	**12**	**12**	**4**
Bolivia	1	6	3	1
Colombia	5	0	0	0
Ecuador	4	3	1	0
Peru	0	3	0	0
Venezuela	16	0	8	3
Southern Cone	**13**	**0**	**0**	**0**
Argentina	0	0	0	0
Brazil	13	0	0	0
Chile	–	–	–	–
Paraguay	0	0	0	0
Uruguay	–	–	–	–
South America	**39**	**12**	**12**	**4**
Latin America	**90**	**36**	**27**	**39**

Source: CIMMYT maize impacts survey.

5 Since the CIMMYT Maize Program does not work with temperate materials, it came as a surprise to learn that CIMMYT germplasm has been present in 30% of all public varieties and hybrids showing adaptation to temperate environments.

CIMMYT Population 43 (La Posta), and the Thai variety Suwan-1, which was developed through a collaborative breeding effort involving scientists from the Rockefeller Foundation, the Department of Agriculture of Thailand, Kasetsart University, and CIMMYT .

National maize breeding programs have used CIMMYT germplasm in different ways (Table 23). A significant proportion of the public-sector releases in Central America and the Caribbean containing CIMMYT germplasm can be characterized as Class 4 cultivars, which are experimental varieties and hybrids distributed by CIMMYT that have simply been given a local name and released with little or no additional improvement at the hands of local breeders. At the other extreme, in the Southern Cone sub-region over 90% of the public-sector releases containing CIMMYT germplasm can be characterized as Class 2 cultivars, which are locally developed varieties and hybrids that contain a relatively small amount of CIMMYT germplasm in their parentage. This pattern provides further evidence that it is efficient for small countries with relatively modest national breeding programs to release CIMMYT varieties and hybrids with little or no additional improvement, whereas it is efficient for large countries with relatively strong national breeding programs to subject promising CIMMYT materials to several additional cycles of selection and/or crossing before releasing locally adapted cultivars.

Table 23. Manner of use of CIMMYT germplasm by public breeding programs, Latin America, 1966-97 (% of cultivars released)

	Cultivars containing CIMMYT germplasm:			
	Class 2	Class 3	Class 4	Total
Central America	**60.4**	**25.2**	**14.4**	**100.0**
Costa Rica	94.4	5.6	0.0	100.0
El Salvador	73.3	13.4	13.3	100.0
Guatemala	63.3	13.3	23.3	100.0
Honduras	35.0	30.0	35.0	100.0
Nicaragua	47.1	52.9	0.0	100.0
Panama	45.5	54.5	0.0	100.0
Caribbean	**42.9**	**14.3**	**42.9**	**100.0**
Cuba	33.3	33.3	33.3	100.0
Dominican Republic	80.0	0.0	20.0	100.0
Haiti	0.0	0.0	100.0	100.0
Mexico	**82.0**	**15.3**	**2.8**	**100.0**
Central America, Caribbean, and Mexico	**67.0**	**20.8**	**12.2**	**100.0**
Andean Zone	**67.6**	**26.1**	**6.3**	**100.0**
Bolivia	51.2	46.5	2.3	100.0
Colombia	58.3	41.7	0.0	100.0
Ecuador	76.9	7.7	15.4	100.0
Peru	61.1	16.7	22.2	100.0
Venezuela	100.0	0.0	0.0	100.0
Southern Cone	**92.4**	**4.5**	**3.0**	**100.0**
Argentina	100.0	0.0	0.0	100.0
Brazil	91.5	8.6	0.0	100.0
Chile	–	–	–	–
Paraguay	80.0	0.0	20.0	100.0
Uruguay	–	–	–	–
South America	**76.8**	**18.1**	**5.1**	**100.0**
Latin America	**71.6**	**19.5**	**8.8**	**100.0**

Source: CIMMYT maize impacts survey.

How has the use of CIMMYT germplasm by national breeding programs changed through time? Figure 4 shows trends in the percentage of public-sector releases containing CIMMYT germplasm, as well as changes in the proportion of these releases falling into each of the three classes (since CIMMYT does not work with temperate germplasm, Figure 4 refers to non-

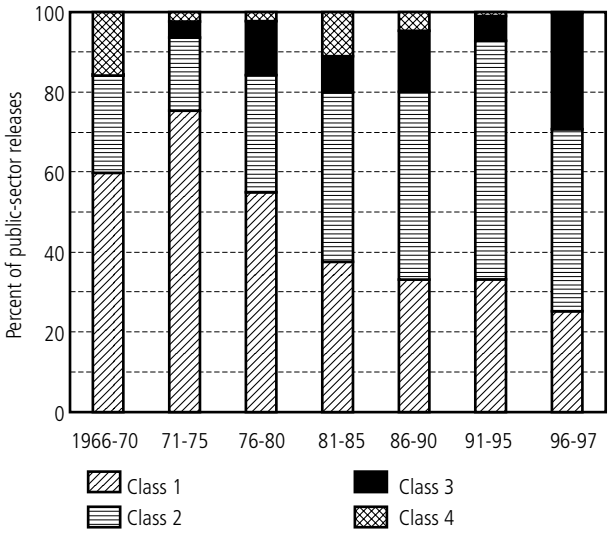

Figure 4. Use of CIMMYT germplasm as source materials by public maize breeding programs, Latin America, 1966-97.

temperate releases only). The use of CIMMYT germplasm by national breeding programs has increased through time, to the extent that today nearly three-quarters of all public varieties and hybrids released in Latin America contain CIMMYT germplasm. At the same time, there has been a marked decrease in the proportion of these releases characterized as Class 4 (direct selection of a CIMMYT experimental variety or hybrid). This indicates that national programs are now much less likely to make direct use of germplasm obtained from CIMMYT; rather, they tend to subjet it to additional cycles of selection before using it to form finished cultivars.

Private breeding programs

To what extent have private seed companies in Latin America made use of CIMMYT germplasm? Until quite recently, attempts to document the use of CIMMYT germplasm by private seed companies had met with little success. In 1992, for example, many private companies declined to participate in the CIMMYT survey. Among the few that agreed to participate, most refused to discuss their use of CIMMYT germplasm, arguing that even general information about the genetic background of specific commercial hybrids is too sensitive to be disclosed. Fortunately, this posture now seems to be changing. Two main factors seem to have contributed to the recent shift in attitude. First, many seed company representatives now understand that CIMMYT has made good on its promise to respect the confidentiality of pedigree information. Second, they have seen that the information about the genetic background of public- and private-sector cultivars is used in a way that is useful to all breeding programs and harmful to none. The change in attitude is very important, because for the first time it has been possible to shed light on an important area that in the past has remained in the dark.

Table 24 presents information on the use of CIMMYT germplasm by private seed companies in Latin America. As in the case of Tables 16-19, the data in Tables 24-27 refer to all proprietary cultivars available in the market in 1997. Because of the multiple-counting problem described earlier (arising because the same proprietary cultivars are often sold in several countries at the same time), sub-regional and regional totals are not included.

Table 24 and Figure 5 make clear that private seed companies in Latin America have made extensive use of CIMMYT germplasm. In every country except Argentina, where most maize is produced in temperate environments, more than 80% of all private-sector (proprietary) materials available in the market in 1997 contained CIMMYT germplasm in their parentage.[6] In many countries the percentage of private-sector cultivars

Table 24. Use of CIMMYT germplasm by private seed companies, Latin America, 1997 (% of proprietary cultivars available on the market)

	Number of cultivars available on the market	Without CIMMYT germplasm (%)	With CIMMYT germplasm:		
			Definitely (%)	Probably (%)	Total CIMMYT (%)
Central America					
Costa Rica	13	0.0	30.8	69.2	100.0
El Salvador	7	14.3	85.7	0.0	85.7
Guatemala	11	9.1	90.9	0.0	90.9
Honduras	21	4.8	81.0	14.3	95.3
Nicaragua	5	0.0	100.0	0.0	100.0
Panama	4	0.0	0.0	100.0	100.0
Caribbean					
Cuba	0	na	na	na	na
Dominican Republic	0	na	na	na	na
Haiti	1	100.0	0.0	0.0	0.0
Mexico	155	18.7	43.2	38.1	81.3
Andean Zone					
Bolivia	15	0.0	40.0	60.0	100.0
Colombia	29	0.0	62.1	37.9	100.0
Ecuador	10	10.0	50.0	40.0	90.0
Peru	6	16.7	50.0	33.3	83.3
Venezuela	65	4.6	80.0	15.4	95.4
Southern Cone					
Argentina	133	71.4	2.3	26.3	28.6
Brazil	122	6.6	9.0	84.4	93.4
Chile	–	–	–	–	–
Paraguay	61	11.5	6.6	82.0	88.6
Uruguay	–	–	–	–	–

Source: CIMMYT maize impacts survey.

containing CIMMYT germplasm exceeded 90%, and in five countries, all proprietary cultivars available in the market in 1997 contained CIMMYT germplasm. These percentages are considerably higher than the figures reported in Table 20 for the public-sector releases, but it should be recalled that the figures referring to public-sector releases were calculated based on cultivars released since 1966. When the focus is restricted to more recent public-sector releases (e.g., cultivars released since 1990), the percentage containing CIMMYT germplasm is similar.

As expected, use of CIMMYT germplasm was concentrated among lowland tropical materials. CIMMYT germplasm was present in relatively few proprietary materials showing adaptation to subtropical/mid-altitude environments, highland environments, and temperate environments (Table 25).

Table 26 shows how CIMMYT germplasm has been used by private seed companies. (The results in Table 26 are based on cultivars definitively known to contain CIMMYT germplasm and specifically classified as belonging to Class 2, Class 3, or Class 4.) The table is dominated by Class 2 materials, indicating that private companies rarely make direct use of CIMMYT varieties and hybrids; instead, they subject them to additional cycles of selection and improvement before releasing them as finished cultivars.

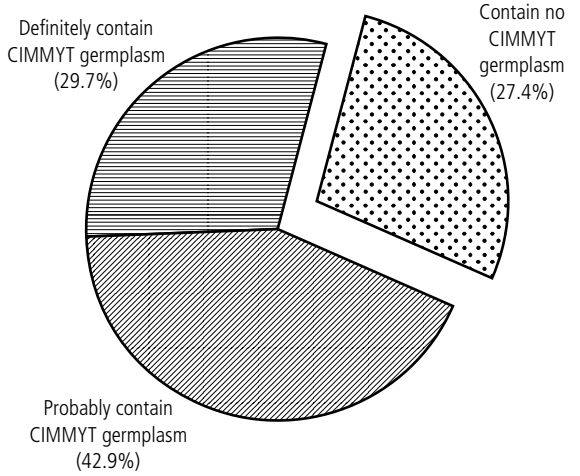

Figure 5. Use of CIMMYT germplasm by the private sector, Latin America (% of all proprietary materials available on the market in 1997).

Not all private seed companies use CIMMYT materials in the same way. Figure 6 shows differences in the way CIMMYT germplasm is used by different types of seed companies. Domestic seed companies are more likely to sell cultivars that are more directly derived from CIMMYT source materials (Class 3), whereas multinationals virtually always make further improvements in CIMMYT source materials before incorporating them into commercial cultivars (Class 2).

The finding that private seed companies use CIMMYT germplasm extensively will come as no surprise to professional maize breeders, most of

Table 25. Ecological adaptation of proprietary cultivars containing CIMMYT germplasm, Latin America, 1997 (% of cultivars available on the market)

	Lowland tropical	Subtropical/ mid-altitude	Highland	Temperate
Central America				
Costa Rica	91.7	8.3	0.0	0.0
El Salvador	100.0	0.0	0.0	0.0
Guatemala	100.0	0.0	0.0	0.0
Honduras	94.7	0.0	5.3	0.0
Nicaragua	100.0	0.0	0.0	0.0
Panama	100.0	0.0	0.0	0.0
Caribbean				
Cuba	na	na	na	na
Dominican Republic	na	na	na	na
Haiti	na	na	na	na
Mexico	60.7	34.4	4.1	0.8
Andean Zone				
Bolivia	100.0	0.0	0.0	0.0
Colombia	100.0	0.0	0.0	0.0
Ecuador	100.0	0.0	0.0	0.0
Peru	100.0	0.0	0.0	0.0
Venezuela	100.0	0.0	0.0	0.0
Southern Cone				
Argentina	5.3	0.0	0.0	94.7
Brazil	96.5	0.0	0.0	3.5
Chile	–	–	–	–
Paraguay	98.1	0.0	0.0	1.9
Uruguay	–	–	–	–

Source: CIMMYT maize impacts survey.

6 The discussion of the use of CIMMYT germplasm by private seed companies omits any mention of the countries of the Caribbean region, since private companies have very little presence in these countries.

whom are well aware that there are considerable (though largely undocumented) flows of germplasm among and between public- and private-sector breeding programs. However, this is the first time that it has been possible to document the extent to which CIMMYT germplasm is present in proprietary cultivars. The fact that private seed companies are making considerable use of CIMMYT germplasm would appear to provide grounds for questioning recent calls to scale back public investment in international maize breeding research, ostensibly because private seed companies would readily assume the breeding functions performed by CIMMYT. The issue will be difficult to resolve, however, until additional information is available about the way in which CIMMYT materials are being used, and by whom. It is hoped that private seed companies will become increasingly cooperative in divulging detailed information about their breeding practices, so that five years from now when the CIMMYT impacts survey is next updated it will be possible to shed additional light on this important issue.

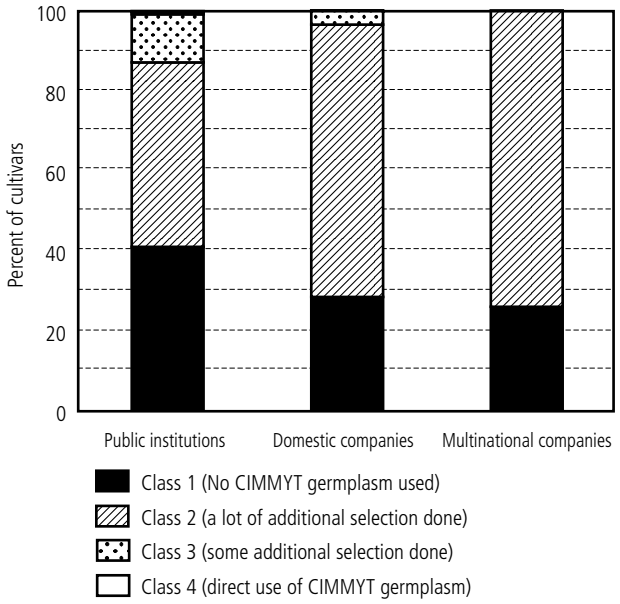

Figure 6. Manner of use of CIMMYT maize germplasm by different types of organizations, Latin America, 1990s.

Table 26. Manner of use of CIMMYT germplasm by private seed companies, Latin America (% of proprietary cultivars available on the market in 1997)

	Cultivars containing CIMMYT germplasm in which manner of use is known with certainty:			
	Class 2	Class 3	Class 4	Total
Central America				
Costa Rica	100.0	0.0	0.0	100.0
El Salvador	100.0	0.0	0.0	100.0
Guatemala	100.0	0.0	0.0	100.0
Honduras	100.0	0.0	0.0	100.0
Nicaragua	100.0	0.0	0.0	100.0
Panama	100.0	0.0	0.0	100.0
Caribbean				
Cuba	na	na	na	na
Dominican Republic	na	na	na	na
Haiti	na	na	na	na
Mexico	96.8	3.2	0.0	100.0
Andean Zone				
Bolivia	100.0	0.0	0.0	100.0
Colombia	100.0	0.0	0.0	100.0
Ecuador	100.0	0.0	0.0	100.0
Peru	100.0	0.0	0.0	100.0
Venezuela	79.0	21.0	0.0	100.0
Southern Cone				
Argentina	100.0	0.0	0.0	100.0
Brazil	100.0	0.0	0.0	100.0
Chile	–	–	–	–
Paraguay	100.0	0.0	0.0	100.0
Uruguay	–	–	–	–

Source: CIMMYT maize impacts survey.

Table 27. Approximate CIMMYT germplasm content of proprietary cultivars, Latin America (% of proprietary cultivars available on the market in 1997)

	Proportion of source germplasm originating from CIMMYT:			
	0%	1-33%	34-67%	68-100%
Central America				
Costa Rica	0.0	84.6	0.0	15.4
El Salvador	14.3	14.3	14.3	57.1
Guatemala	9.1	27.3	27.3	36.4
Honduras	4.8	23.8	52.4	19.0
Nicaragua	0.0	40.0	40.0	20.0
Panama	0.0	100.0	0.0	0.0
Caribbean				
Cuba	na	na	na	na
Dominican Republic	na	na	na	na
Haiti	100.0	0.0	0.0	0.0
Mexico	18.7	44.5	30.3	6.5
Andean Zone				
Bolivia	0.0	100.0	0.0	0.0
Colombia	0.0	62.1	6.9	31.0
Ecuador	10.0	70.0	20.0	0.0
Peru	16.7	50.0	16.7	16.7
Venezuela	4.6	35.4	21.5	38.5
Southern Cone				
Argentina	71.4	28.6	0.0	0.0
Brazil	6.6	86.1	7.4	0.0
Chile	–	–	–	–
Paraguay	11.9	88.1	0.0	0.0
Uruguay	–	–	–	–

Source: CIMMYT maize impacts survey.