Impacts of CIMMYT's Maize Breeding Program

The CIMMYT Maize Program, working out of its headquarters in Mexico and out of regional offices located in Central and South America, sub-Saharan Africa, and Asia, produces improved germplasm that is distributed to public and private breeding programs around the world for use in developing finished varieties. Since CIMMYT does not release finished varieties, the impacts of CIMMYT's maize breeding efforts are best estimated by investigating the extent to which CIMMYT germplasm has been used by public and private breeding programs. This is not an easy task. Tracking the use of CIMMYT germplasm is difficult for several reasons. To begin with, modern maize breeding is an extremely complex undertaking. The development of OPVs and hybrids normally involves repeated cycles of crossing involving a wide range of source materials; consequently, it is often very difficult to trace the complete genetic history of individual varieties. Documenting the origins of individual varieties is greatly complicated by the fact that the pedigrees (genetic background and crossing history) of most commercial hybrids are confidential, since most private breeding programs and even some public ones are reluctant to disclose pedigree information for fear of providing information that might be useful to potential competitors.

Table 17. Maturity classes of maize varieties (available in 1998) released by private seed companies, eastern and southern Africa (number of varieties)

Country / region	Extra early	Early	Intermediate	Late	Extra late
Ethiopia	0	0	1	0	0
Kenya	2	0	3	0	0
Uganda	0	0	0	0	0
Eastern Africa	3	0	4	0	0
Angola	0	0	0	0	0
Lesotho	0	0	0	0	0
Malawi	0	1	1	1	0
Mozambique	0	2	1	3	0
South Africa	2	8	19	18	15
Swaziland	0	0	0	0	0
Tanzania	0	0	1	0	0
Zambia	0	0	0	2	0
Zimbabwe	0	4	7	12	11
Southern Africa	2	15	29	36	26
Southern Africa, excluding South Africa	0	7	10	18	11
Eastern and southern Africa	5	15	33	36	26
Eastern and southern Africa, excluding South Africa	3	7	14	18	11

Source: CIMMYT Maize Research Impacts Survey, 1998/99.

Despite these difficulties, for this study an attempt was made to compile information on the use of CIMMYT-derived germplasm by public and private maize breeding programs in eastern and southern Africa. Although it was not possible to obtain complete pedigree information for most varieties, especially commercial hybrids developed by private seed companies, the survey respondents were asked the following three questions about each cultivar that had been developed by their breeding program:

1. Does the cultivar contain CIMMYT germplasm?
2. If it does contain CIMMYT germplasm, which CIMMYT population(s), pool(s), and / or inbred line(s) were used in developing the cultivar?
3. How were the CIMMYT population(s), pool(s), and / or inbred line(s) used? [5]

In the analysis that follows, data for southern Africa are often reported in two ways: (a) including South Africa, and (b) excluding South Africa. South Africa is sometimes excluded from the analysis because commercial maize hybrids cultivated in South Africa contain mainly temperate germplasm, most of which comes from the US and Europe. CIMMYT maize breeders do not work with temperate germplasm, so most of South Africa's maize-growing area falls outside the area targeted

[5] For information about the survey instrument, see Morris and López-Pereira (1998).

by the CIMMYT Maize Program. In assessing the impacts of CIMMYT's breeding efforts, it is therefore often appropriate to exclude South Africa.

Use of CIMMYT Germplasm

Of all maize varieties released by public and private breeding programs since 1966 and whose parentage is known, 24% were developed using CIMMYT source materials (35% if South Africa is excluded).

Use of CIMMYT germplasm has varied by region and by type of breeding program (Table 18). Among public breeding programs, use of CIMMYT germplasm has been more extensive in southern Africa (35% of all public-sector releases for which the CIMMYT germplasm content is known contain CIMMYT germplasm) than in eastern Africa (22% of all releases for which the CIMMYT germplasm content is known contain CIMMYT germplasm). Among private breeding programs, the pattern is reversed; use of CIMMYT germplasm has been more extensive in eastern Africa (67% of all private-sector releases for which the CIMMYT germplasm content is known contain CIMMYT germplasm) than in southern Africa (15% of all releases for which the CIMMYT germplasm content is known contain CIMMYT germplasm; 44% if South Africa is excluded). In interpreting these percentage figures, it is important to remember that the total number of private-sector releases is approximately 10 times higher than the number of public-sector releases.

Aggregating across both regions (eastern and southern Africa) and both types of breeding programs (public and private), CIMMYT germplasm shows up much more frequently in OPVs than in hybrids (Table 18).

How has the use of CIMMYT germplasm changed through time? Trends in the use of CIMMYT germplasm are shown in Table 19 and Figure 4. In both regions, use of CIMMYT germplasm has increased steadily among public and

Table 18. Use of CIMMYT germplasm by public and private breeding programs, eastern and southern Africa, 1966-98

	Percentage of all public releases developed using CIMMYT germplasm[a]			Percentage of all private releases developed using CIMMYT germplasm[a]			
Country / region	**OPVs**	**Hybrids**	**Total**	**OPVs**	**Hybrids**	**Total**	**Grand total**
Ethiopia	25.0	50.0	36.4	0.0	0.0	0.0	33.3
Kenya	25.0	0.0	10.5	0.0	40.0	100.0	19.0
Uganda	50.0	0.0	50.0	0.0	0.0	0.0	50.0
Eastern Africa	27.8	11.8	21.9	0.0	33.3	66.7	25.7
Angola	-	-	-	-	-	-	-
Lesotho	-	-	-	-	-	-	-
Malawi	77.8	33.3	55.6	0.0	0.0	0.0	55.6
Mozambique	100.0	0.0	100.0	33.3	0.0	33.3	75.0
South Africa	0.0	0.0	0.0	0.0	2.9	2.9	2.9
Swaziland	-	-	-	-	-	-	-
Tanzania	60.0	0.0	54.5	50.0	0.0	50.0	53.8
Zambia	40.0	5.9	13.6	0.0	0.0	0.0	12.5
Zimbabwe	-	-	-	33.3	30.0	50.0	31.3
Southern Africa	58.8	9.3	35.3	37.5	10.4	14.7	23.3
Southern Africa, excluding South Africa	58.8	9.3	35.3	37.5	23.7	44.4	37.9
Eastern and southern Africa	48.1	10.0	31.0	37.5	11.6	16.3	23.7
Eastern and southern Africa, excluding South Africa	48.1	10.0	31.0	37.5	25.0	46.7	34.6

Source: CIMMYT Maize Research Impacts Survey, 1998/99.

[a] Percentage of releases whose CIMMYT germplasm content is known.

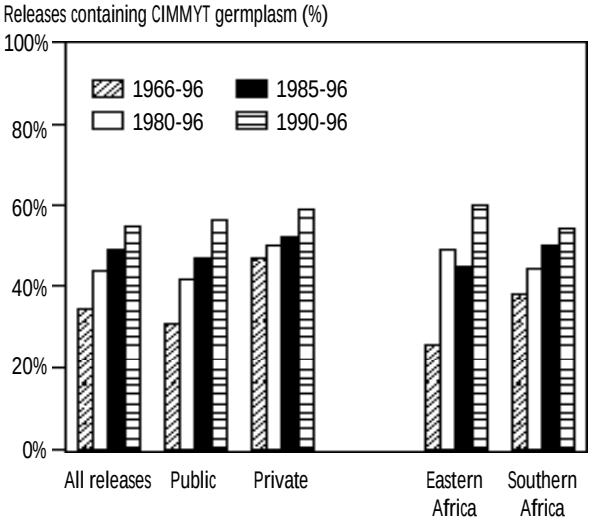

Figure 4. Use of CIMMYT maize germplasm, eastern and southern Africa, 1966-96
Source: CIMMYT Maize Research Impacts Survey, 1998/99.

private breeding programs. During the 1990s, 50% of all public-sector releases in eastern Africa contained CIMMYT germplasm, as did 53% of all public-sector releases in southern Africa (excluding South Africa). During the same period, 100% of all private-sector releases in eastern Africa contained CIMMYT germplasm, as did 55% of all private-sector releases in southern Africa (excluding South Africa). Aggregating the data for both regions and for both types of breeding program, 31% of all varieties released during the 1990s contained CIMMYT germplasm (55% if South Africa is excluded), indicating strong and increasing demand for CIMMYT germplasm. The observed growth in the use of CIMMYT germplasm during recent years strongly validates the decision of the CIMMYT Maize Program to establish a breeding station within the region to concentrate on local adaptive breeding.

Table 19. Trends in use of CIMMYT germplasm by public and private breeding programs, eastern and southern Africa, 1966-98

	Percentage of all public releases developed using CIMMYT germplasm[a]				Percentage of all private releases developed using CIMMYT germplasm[a]				Percentage of all releases developed using CIMMYT germplasm[a]			
Country / region	**1966-96**	**1980-96**	**1985-96**	**1990-96**	**1966-96**	**1980-96**	**1985-96**	**1990-96**	**1966-96**	**1980-96**	**1985-96**	**1990-96**
Ethiopia	36.4	50.0	50.0	50.0	-	-	-	-	33.3	50.0	50.0	50.0
Kenya	10.5	20.0	22.2	33.3	100.0	100.0	100.0	100.0	19.0	33.3	36.4	60.0
Uganda	50.0	100.0	100.0	100.0	0.0	-	-	-	50.0	100	100	100
Eastern Africa	21.9	36.8	38.9	50.0	66.7	100.0	100.0	100.0	25.7	42.9	45.0	60.0
Angola	-	-	-	-	-	-	-	-	-	-	-	-
Lesotho	-	-	-	-	-	-	-	-	-	-	-	-
Malawi	55.6	62.5	71.4	69.2	0.0	0.0	0.0	0.0	55.6	62.5	71.4	69.2
Mozambique	100.0	100.0	100.0	100.0	33.3	33.3	33.3	50.0	75.0	75.0	71.4	80.0
South Africa	-	-	-	-	2.9	2.9	2.9	3.7	2.9	2.9	2.9	3.7
Swaziland	-	-	-	-	-	-	-	-	-	-	-	-
Tanzania	54.5	71.4	50.0	66.7	50.0	50.0	50.0	0.0	53.8	66.7	50.0	66.7
Zambia	13.6	15.8	20.0	22.2	0.0	0.0	0.0	0.0	12.5	14.3	16.7	18.2
Zimbabwe	-	0.0	0.0	0.0	50.0	52.6	55.6	62.5	31.3	40.0	47.6	55.6
Southern Africa	35.3	43.4	51.4	53.3	14.7	14.9	15.1	17.6	23.3	25.2	25.0	27.9
Southern Africa, excluding South Africa	35.3	43.4	51.4	53.3	44.4	46.2	48.0	55.0	37.9	44.3	50.0	54.0
Eastern and southern Africa	31.0	41.7	47.2	52.6	16.3	16.7	16.8	19.7	23.7	27.4	27.7	30.7
Eastern and southern Africa, excluding South Africa	31.0	41.7	47.2	52.6	46.7	50.0	51.9	59.1	34.6	44.0	48.8	55.0

Source: CIMMYT Maize Research Impacts Survey, 1998/99.
[a] Percentage of releases whose CIMMYT germplasm content is known.

How has use of CIMMYT germplasm varied across ecological zones? In both regions, public and private breeding programs have used CIMMYT germplasm most frequently in developing varieties targeted for tropical lowland and mid-altitude tropical environments (Table 20). Use of CIMMYT germplasm in developing highland materials has been more variable; none of the highland varieties released in eastern Africa contained CIMMYT material, compared to 40% of the highland varieties released in southern Africa. One interesting finding is that public and private breeding programs have made use of CIMMYT germplasm in developing varieties targeted for temperate production environments; 40% of the temperate varieties developed by Kenyan breeding programs and 14.3% of the temperate varieties developed by South African breeding programs have contained CIMMYT germplasm.

Simply knowing whether or not a variety was developed using CIMMYT germplasm provides a useful measure of the impact of CIMMYT's maize breeding program. Even more useful would be quantitative information about the importance of CIMMYT germplasm in the genetic makeup of each cultivar (i.e., the percentage share of CIMMYT germplasm). In the absence of complete pedigree information, unfortunately it was not possible to calculate such a measure.

Popular CIMMYT Materials

Survey respondents were generally reluctant to provide details about the use of particular CIMMYT population(s), pool(s), and/or inbred line(s), so this information was obtained for relatively few varieties. Within the limited sample for which data were available, Population 21 (Tuxpeño) was the most

Table 20. Percentage of public and total maize varietal releases containing CIMMYT germplasm, by ecological zone, eastern and southern Africa[a]

	Public releases				Total releases			
Country/region	Lowland tropics	Subtropics, mid-altitude	Highland tropics	Temperate areas	Lowland tropics	Subtropics, mid-altitude	Highland tropics	Temperate areas
Ethiopia	0.0	36.4	-	-	0.0	33.3	-	-
Kenya	100	8.3	0.0	0.0	100.0	8.3	0.0	40.0
Uganda	-	50.0	-	-	-	50.0	-	-
Eastern Africa	50.0	24.0	0.0	0.0	50.0	23.1	0.0	40.0
Angola	-	-	-	-	-	-	-	-
Lesotho	-	-	-	-	-	-	-	-
Malawi	54.6	57.1	-	-	50.0	66.7	-	-
Mozambique	100.0	100.0	-	-	25.0	71.4	-	-
South Africa	-	-	-	-	100.0	1.9	-	14.3
Swaziland	-	-	-	-	-	-	-	-
Tanzania	-	57.1	50.0	-	-	62.5	40.0	-
Zambia	50.0	5.0	-	-	100.0	4.6	-	-
Zimbabwe	0.0	0.0	-	-	0.0	20.0	-	-
Southern Africa	40.9	27.7	50.0	-	22.7	18.2	40.0	14.3
Southern Africa, excluding South Africa	40.9	27.7	50.0	-	34.6	28.1	40.0	-
Eastern and southern Africa	41.7	26.4	22.2	0.0	37.9	18.9	40.0	33.3
Eastern and southern Africa, excluding South Africa	41.7	26.4	22.2	0.0	35.7	27.0	40.0	40.0

Source: CIMMYT Maize Research Impacts Survey, 1998/99.
[a] Percentage of releases whose CIMMYT germplasm content is known.

popular CIMMYT source material, followed by Population 22 (Mezcla Tropical Blanco) and Population 32 (ETO Blanco). All three of these populations are adapted to lowland topical environments.

Manner of Use of CIMMYT Germplasm

Public and private breeding programs in eastern and southern Africa have tended to use CIMMYT germplasm in different ways (Table 21). Public breeding programs have made extensive use of CIMMYT populations, pools and experimental varieties; most of the time, the CIMMYT source materials have been used directly, with little or no additional selection. In contrast, private seed companies have used mainly CIMMYT inbred lines; in most cases, the CIMMYT lines were subjected to further selection before being used.

Aggregating across public and private breeding programs, among all varieties that were developed using CIMMYT germplasm, in 43% of cases CIMMYT source materials were incorporated with little or no additional improvement at the hands of local breeders. Conversely, in 57% of cases CIMMYT source materials were further improved before being used. This suggests that although many national breeding programs have developed the capacity to do their own improvement work, a considerable number of breeding programs—especially public breeding programs—continue to make direct use of CIMMYT germplasm.

Table 21. Manner of use of CIMMYT source materials by public and private breeding programs, eastern and southern Africa, 1966-98 (% of varietal releases)[a]

Level of improvement	Public releases	Private releases	All releases
No additional improvement of material	25.8	0.0	17.0
No improvement of hybrids/inbred lines	0.0	0.0	0.0
Some improvement of material	32.3	12.5	25.5
Some improvement of hybrids/inbred lines	0.0	0.0	0.0
Substantial improvement of material	41.9	25.0	36.2
Substantial improvement of hybrids/inbred lines	0.0	62.5	21.3

Source: CIMMYT Maize Research Impacts Survey, 1998/99.

[a] Percentage of varietal releases whose manner of use CIMMYT source materials is known.

Farm Level Impacts of Maize Breeding Research

Previous sections of this report have presented information about the numbers and types of maize varieties that have been produced by public and private breeding programs in eastern and southern Africa, as well as information about the CIMMYT germplasm content of these varieties. Information about varietal releases provides an important measure of the productivity of breeding programs, but it does not provide a complete measure of the impacts of breeding programs on maize production. Improved varieties are able to increase maize production and to improve farmers' incomes and welfare only when they are planted in farmers' fields. In assessing the impacts of public and private maize breeding efforts, it is therefore important to estimate the extent to which modern varieties have been adopted by farmers and to estimate the resulting productivity gains.

The most reliable way to measure the adoption of modern varieties is through farm-level surveys. Unfortunately, relatively few of the countries covered by this report have carried out comprehensive national surveys in recent years to document farmers' use of improved maize varieties. Only in Kenya (Hassan et al. 1998), Tanzania (Moshi et al. 1997), and Malawi (Smale and Heisey 1997) have national surveys been carried out.

In the absence of survey data, it is necessary to rely on alternative sources of information to estimate varietal adoption rates. For this report, two methods were used to estimate farmers' use of improved