

As part of the overall CGIAR 2005 annual performance measurement exercise, the Science Council received 30 individual case studies of Center impact. These were the best examples of impact assessments done by the Centers during 2003–2005. The Science Council's Standing Panel on Impact Assessment (SPIA) identified six of these as being particularly meritorious in terms of quality of analysis and presentation. In recognition of these studies as good examples of emerging 'best practice', SPIA has, with the relevant Center's concurrence, prepared Science Council/SPIA Briefs on each. Publishing quality impact briefs responds to continued calls from donors to the CGIAR for more documented evidence of impacts to be made available in the form of such concise publications.



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Impacts of International Wheat Breeding in the Developing World

In its third and most recent global wheat survey, the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) documents the huge impacts that international wheat breeding research continues to have on wheat production in the developing world.¹ Between 1988 and 2002, public national research organizations and private companies in the developing world released nearly 1700 new wheat varieties, one-third of them after 1997, the end-date of CIMMYT's previous survey. In this 2002 survey, for the first time, data from several countries in eastern Europe and the former Soviet Union are included.

This survey shows that CIMMYT germplasm continues to be used extensively by wheat breeders in both the public and private sectors. Of all the wheat varieties with known pedigrees released in developing countries between 1988 and 2002, about 75 per cent have some CIMMYT ancestry. Although direct use of CIMMYT-derived varieties has decreased since the time of the previous survey, their indirect use in national breeding programs has increased as these programs have grown and developed. Predictions that private companies would be reluctant to use public germplasm because of concerns about ownership rights seem to have been unfounded.

In 2002, nearly 95 per cent of the developing world's total wheat area of 96 million hectares was sown to modern varieties. Of this area, 68 per cent (62 million hectares) was sown to varieties containing some CIMMYT germplasm. Analysis of the rate at which farmers adopt new varieties, inferred by examining the age of the varieties being grown in 2002, shows that many new varieties were taken up quickly, although some of the varieties released in the 1980s and even earlier were still being grown. Concerns that the success of CIMMYT's wheat breeding program is reducing genetic diversity in farmers' fields, thereby increasing farmers' vulnerability to crop losses, are countered by molecular-level analysis showing that the diversity present in recent CIMMYT lines has increased substantially because breeders are making use of so many different sources of genetic material.

The value of the extra grain produced as a result of the adoption of modern wheat varieties is enormous. Using 2002 adoption data, CIMMYT calculated that the additional annual production attributable to international wheat breeding research is at least 14 million tonnes, based on conservative assumptions, and could be as much as 41 million tonnes. In monetary terms, the total value of that additional production is US\$2–6 billion. This puts the annual benefit associated with CIMMYT-derived wheat germplasm in 2002 at US\$0.5–1.5 billion or US\$1.3–3.9 billion, depending on the assumptions used. In either case, the sum is equivalent to many times CIMMYT’s annual investment in wheat breeding research.

Release of new varieties

CIMMYT’s third global wheat survey, covering the years 1998–2002, is based on data gathered from 43 countries, including for the first time 17 countries in Eastern Europe and the former Soviet Union. Over this period, the average number of new releases each year was highest in Eastern Europe and the former Soviet Union (33) and lowest in eastern and southern Africa (6). However, using the more meaningful measure of number of varieties released per million hectares sown to wheat, the release rates for wheat varieties were highest in Latin America and eastern and southern Africa, and lowest in India and China. Spring bread wheats dominated the releases (66 per cent of all releases between 1998 and 2002), reflecting the importance of these wheats in the developing world (where they were sown on 63 per cent of the total wheat area in 2002).

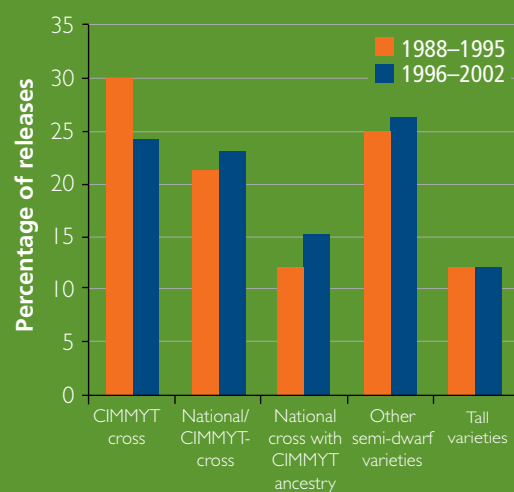
The extent of CIMMYT’s contribution to new wheat releases can be revealed by classifying modern wheat varieties according to one of five categories:

1. CIMMYT-bred releases
2. National program crosses, involving one or more CIMMYT parents
3. National program crosses, containing CIMMYT-related germplasm from previous generations (grandparent stage or earlier)
4. Semi-dwarf varieties (scientifically bred) without CIMMYT germplasm
5. Tall varieties (scientifically bred) without CIMMYT germplasm.

Analysis using these categories shows that about 75 per cent of all wheat varieties with known pedigrees released in developing countries between 1988 and 2002 contained CIMMYT-related germplasm. Comparison of the period 1988–1995 with the period 1996–2002 shows that the proportion of CIMMYT-bred releases (Category 1) has declined slightly (down from 30 per cent to 24 per cent), while the proportion of releases from national programs that contain CIMMYT germplasm has increased (up from 21 per cent to 23 per cent for Category 2 and from 12 per cent to 15 per cent for Category 3 – see Figure 1). These data provide an example of the strong synergies that have evolved between CIMMYT and national programs.

Although international wheat breeding in developing countries is dominated by the public sector, the private sector also makes a contribution, which varies among countries and varieties. CIMMYT’s survey showed that, over the period 1998–2002, private companies developed 20 per cent of all spring bread wheat releases. Of this proportion, private companies in Eastern Europe and the former Soviet Union contributed the most (38 per cent), followed by eastern and southern Africa (34 per cent), and Latin America (34 per cent). The private-sector contribution in East and South Asia was negligible. Predictions that agreements to protect plant breeders’ rights might lead

Figure 1. Wheat varietal releases in the developing world, 1988–95 and 1996–2002



Source: Lantican et al. (2005).¹

private companies to avoid the use of CIMMYT germplasm, because of concerns about ownership, seem to have been unfounded. The CIMMYT survey showed that, at least for the sample of four Latin American countries examined (Argentina, Brazil, Chile, and Uruguay), use of CIMMYT germplasm by the private sector in protected varieties was high (76–83 per cent). In South Africa, although use of CIMMYT germplasm in the private sector was lower, it was still considerable (45 per cent), given its limited suitability for some of the production environments in that country.

Adoption of released varieties

CIMMYT's survey showed that, in 2002, 91.2 million hectares (nearly 95 per cent) of the developing world's wheat area (95.9 million hectares) was sown to modern varieties (Table 1). The area sown to varieties containing CIMMYT germplasm was 62.1 million hectares (nearly 65 per cent of the total wheat area), showing that varieties with direct or indirect CIMMYT ancestry continue to be used extensively.

The proportion of CIMMYT-related varieties grown is particularly high for spring bread wheats (80 per cent – 48 million hectares). These are the main focus of CIMMYT's wheat breeding efforts and by far the most widely grown type of wheat in the developing world, accounting for almost two thirds (60 million hectares)

of its total wheat area. The inclusion of Eastern Europe and the former Soviet Union in the 2002 survey has markedly increased the figure for the total area sown to winter wheat compared with the earlier surveys. The proportion of CIMMYT-related varieties of winter bread wheat grown in 2002 was relatively low (33 per cent, or 9.8 of 29.3 million hectares), because breeding winter wheat has not been a priority for CIMMYT in the past since it was not extensively grown in the areas previously covered by CIMMYT's remit.

In 2002, several wheat varieties developed in partnership between CIMMYT and national programs were each sown on more than 100,000 hectares (three varieties on more than 1 million hectares each). The most popular was the spring bread wheat derived from an Attila cross, which in 2002 was sown on 5.7 million hectares, mainly in Chile, Ethiopia, India, Iran, and Pakistan. Many CIMMYT-derived varieties released during the 1980s were still being grown; for example, the spring bread wheat Bobwhite (released in 1988) was grown on nearly 1 million hectares, mostly in Argentina and Paraguay. Although most of the CIMMYT-derived varieties released in the 1970s had been replaced by newer ones, the spring bread wheat Sonalika, released in 1970, was still being grown in 2002 on more than 1 million hectares in India and Bangladesh. These findings provide evidence of the time-lag before new releases are adopted by farmers, which can be lengthy in more marginal environments.

Table 1.
Area (million ha) sown to wheat, classified by origin of germplasm, 2002

	CIMMYT cross	CIMMYT parent ^a	CIMMYT ancestor ^a	Other semi-dwarfa	Talla	Landraces	All
Spring bread wheat	19.3	22.3	6.5	5.4	4.8	1.7	60.0
Spring durum wheat	2.3	1.0	0.8	0.2	0.1	0.5	4.8
Winter bread wheat	0.7	1.5	7.6	11.2	5.7	2.6	29.3
Winter durum wheat	0.0	0.1	0.0	0.1	1.7	0.0	1.8
All wheat types	22.3	24.9	14.9	16.9	12.2	4.8	95.9

^a National crosses

Source: Lantican et al. (2005).¹

Value of international breeding

In monetary terms, the value of international wheat breeding efforts for the developing world in a given year can be estimated by using a simple economic model:

$$B = AyP$$

Where: B is the value of additional production attributable to wheat breeding research, A is the area planted to modern varieties, y is the yield gain attributable to wheat breeding research, and P is the price of wheat grain. Since the yield gain (y) attributable to breeding research can be difficult to separate from other factors that influence yield, CIMMYT based its estimates on figures derived from its own experimental yield data and those in the wheat breeding literature. A conservative estimate of 0.15 t/ha, a generous estimate of 0.45 t/ha, and two intermediate values were used. For the price (P), which varies between and within countries, CIMMYT used an international reference value of US\$150/t, based on the North American export price (hard red winter wheat, Free on Board US Gulf Ports) in 2002.

Using this model and data from the 2002 survey, CIMMYT estimated that the additional amount of wheat produced in developing countries and attributable to wheat breeding research was 14–41 million tonnes, with a total value of US\$2.0–6.1 billion.

To estimate the amount of this huge sum attributable to its own wheat breeding efforts, CIMMYT used four different rules for apportioning credit to CIMMYT.

Using a conservative rule, which assigns the least amount of credit to CIMMYT (crediting CIMMYT crosses only), gave an annual estimate of US\$0.5–1.5 billion for CIMMYT's contribution. Using a liberal rule, which assigns the most credit to CIMMYT (crediting any release with CIMMYT ancestry), gave an estimate of US\$1.3–3.9 billion. Estimates of the cost of CIMMYT's wheat breeding research during 2002 are US\$9–11 million, which suggests that the benefit – cost ratio lies between 50 and 390 to 1. These figures do not take into account benefits other than yield gains, such as improved grain quality, improved straw quality and quantity, and shorter growing cycles. Such benefits are important and can sometimes exceed the yield benefits.

High returns

CIMMYT's most recent survey of international wheat breeding in developing countries shows that the Center's improved germplasm continues to be used extensively by wheat breeders in these countries. A large proportion of the area planted to wheat in the countries surveyed by CIMMYT in 2002 was sown with modern varieties containing CIMMYT germplasm. The survey provides evidence of the strong synergies that exist among CIMMYT and many collaborating public and private wheat programs, with CIMMYT playing a leading role and acting as a catalyst. The survey confirms that public investment in international wheat breeding research continues to generate high rates of return, and enormous benefits in and for developing countries.

Notes

- 1 The full version of the study on which this brief is based is: Lantican M.A., Dubin H.J., and Morris M.L. 2005. *Impacts of International Wheat Breeding Research in the Developing World, 1988–2002*. Centro Internacional de Mejoramiento de Maíz y Trigo: Mexico DF, Mexico. The study is available at <http://impact.cgiar.org/>



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