Chapter 3

Trends in Wheat Varietal Releases in Developing Countries, 1966-97

Rates of Varietal Release

National research systems of developing countries released about 2,200 wheat varieties between 1966 and 1997. Of these, one-fourth were released from 1991 to 1997, the most recent period for which data are available. The number of wheat varieties released annually by NARSs doubled between 1966 and the mid-1980s, when it leveled off at about 80 releases per year (Figure 3.1). Average annual releases for China and India reached their highest levels between 1981 and 1985. In Latin America, the number of average annual releases peaked between 1986 and 1990, and in the WANA region between 1991 and 1997. The number of average annual releases for sub-Saharan Africa showed little change between 1966 and 1997.

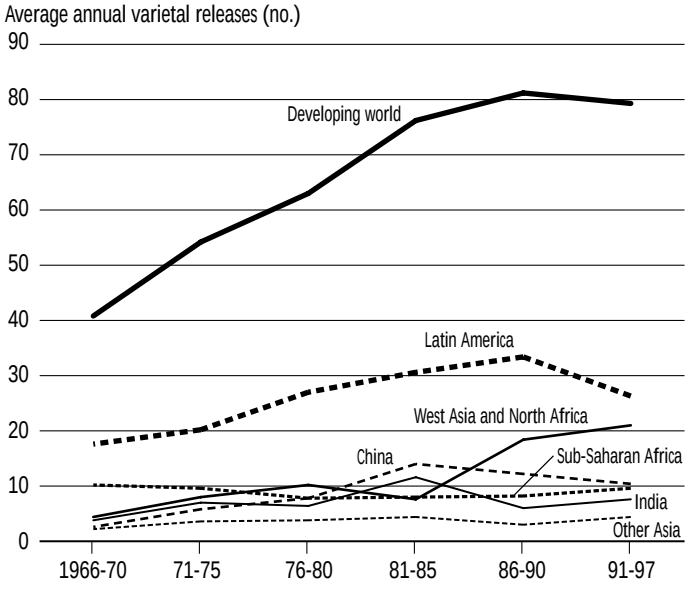

Figure 3.1. Average annual wheat varietal releases by region, 1966-97.

The number of releases is in general not congruent with the size of the wheat area in a country (Byerlee and Moya 1993). An alternative measure of the rate at which varieties are released is the number of varieties released each year per million hectares planted to wheat. For instance, Latin America and sub-Saharan Africa released far more varieties per unit of wheat area than the rest of the developing world (Byerlee and Moya 1993; Figure 3.2). Higher rates of release in these regions may be associated with smaller wheat areas, greater diversity in MEs (that is, in the target environments for wheat research), faster change in disease complexes, and greater private sector participation in wheat improvement.

Consistent with the pattern for numbers of releases, the average number of varieties released each year per million hectares in all developing countries increased until the mid-1980s and fluctuated thereafter. In the past 15 years, the greater number of releases in the WANA region somewhat counteracted lower rates of release in China and India (Figure 3.1; Figure 3.2). The lower rates of release in these two large producers with strong and mature wheat programs are probably indicative of more precise varietal targeting and not of declines in investment. Furthermore, as previously noted, large producers tend to release fewer wheat varieties per unit area than smaller producers.

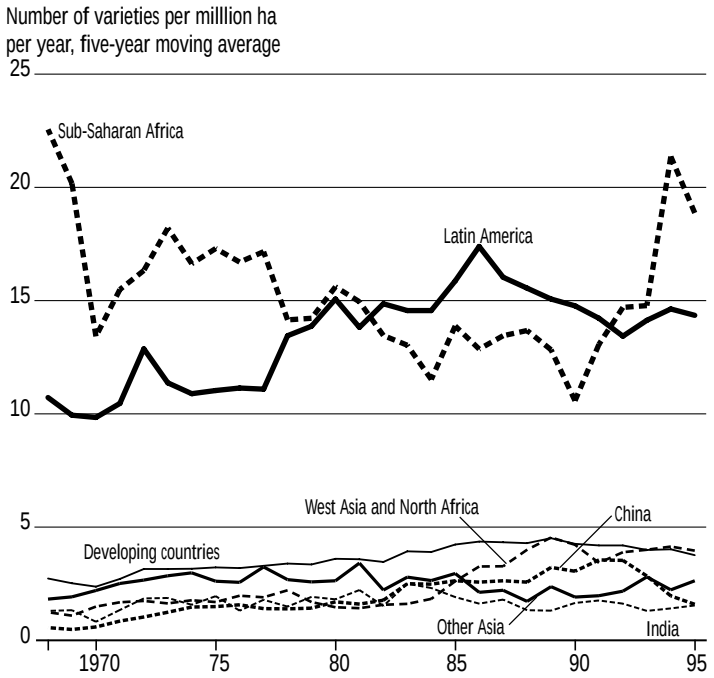

Figure 3.2. Rate of release of wheat varieties, normalized by wheat area, 1966-97.

Wheat Growth Habit, Production Environments, and Varietal Releases

Byerlee and Moya (1993) classified wheat varieties released in developing countries between 1966 and 1990 by wheat type or growth habit in each of three targeted ecological niches—irrigated/well-watered, dry, or both. In our analysis, we classified wheat varieties by growth habit and environmental classification.

Spring bread wheat releases dominate varieties released in the developing world. Though spring bread wheat releases as a percentage of total wheat releases has fallen from over 80% in 1970 to over 70% in the 1990s, this percentage is still higher than spring bread wheat's percentage of total wheat area. About two-thirds of all wheat area in developing countries consists of spring bread wheat (see Table 3.2). Spring durum wheat releases comprised about 6% of all releases in the 1960s, and made up about 10% in the 1990s. Spring durum wheat constitutes a little over 6% of all wheat area. Winter wheat releases reached their highest level (19%) in the 1990s, but this is still lower than the amount of total developing country wheat area covered by this wheat type.

Since many varieties are recommended for more than one moisture regime, we classified varietal releases between 1991 and 1997 into seven categories: irrigated; rainfed well-watered; rainfed dry; irrigated/well-watered; irrigated/rainfed dry; well-watered/rainfed dry; or all moisture regimes. Thirty-four percent of spring bread wheat releases, 25% of winter bread wheat releases, and 16% of spring durum wheat releases were recommended only for irrigated areas. In total, 53% of spring bread wheat releases, 49% of winter bread wheat releases, and 30% of spring durum wheat releases were recommended for irrigated areas. About one-third of winter bread and spring durum wheat releases were recommended only for rainfed dry areas. Over half of all winter bread and spring durum releases were recommended for dry areas (Table 3.1). These figures roughly confirm the importance of irrigated spring bread wheat areas and dry spring durum wheat areas. They also confirm the split in the importance of winter wheat areas between considerable irrigated land, particularly in China, and considerable dry land, particularly in the WANA region.

In South and East Asia, the emphasis in spring bread wheat releases has been on irrigated areas. In Latin America, the most frequently targeted moisture regime has been well-watered rainfed areas. In these large regions, therefore, the release pattern for 1991-97 has not changed much from earlier years (Byerlee and Moya 1993). In contrast,

releases in WANA have shifted in favor of rainfed dry areas, indicating that the priority assigned to drier areas by NARSs in the region in recent years has paid off in increased releases. At the same time, spring bread wheat releases in sub-Saharan Africa were targeted more towards irrigated areas in 1991-97 than earlier years, despite the fact that irrigated wheat represents only one-sixth of wheat area in that region. This was probably the result of relatively high rates of releases in recent years in African countries that grow irrigated wheat, such as Zimbabwe, compared with those that do not.

Although some releases were targeted at more than one ME, our analysis by ME considered only the first-mentioned target ME as the basis for classification. On a global basis, the number of spring bread wheat releases by the first targeted ME is more or less congruent with the wheat area in a given ME for most smaller MEs (3-6), with the exception of ME 6, which is under-represented in releases. However, a larger proportion of spring bread wheat releases are targeted to high-rainfall areas (ME 2), and a lower proportion to favorable irrigated areas (ME 1), relative to the areas actually planted (Tables 3.2 and 2.2). This finding is related to the importance of releases for ME 2 in Latin America, which has a relatively high rate of releases (Figures 3.1 and 3.2). On a regional basis, the congruence between release proportions and actual areas planted is less apparent.[15]

Table 3.1. Distribution (%) of wheat varieties released in developing countries, by wheat type and moisture regime, 1991-97.

	Percentage recommended for:						
Wheat type / region	**Irrigated**	**Rainfed well-watered**	**Rainfed dry**	**Irrigated / Rainfed well-watered**	**Irrigated / Rainfed dry**	**Rainfed well-watered / Rainfed / dry**	**All three moisture regimes**
Spring bread wheat							
Sub-Saharan Africa	52	20	8	0	17	3	0
West Asia and North Africa	20	16	42	15	0	2	5
South and East Asia	53	6	8	0	33	0	0
Latin America	21	36	15	0	4	23	1
All spring bread wheat	34	20	18	3	14	9	2
Winter / facultative bread wheat	25	17	32	4	19	2	1
Spring durum wheat	16	25	31	0	14	14	0
All wheat	30	20	22	3	15	9	1

Table 3.2. Distribution (%) of spring wheat varieties released in developing countries, by wheat type and mega-environment, 1991-97.

	Mega-environment							
Wheat type	**ME 1**	**ME 2**	**ME 3**	**ME 4A**	**ME 4B**	**ME 4C**	**ME 5**	**ME 6**
Spring bread wheat								
Sub-Saharan Africa	62	21	3	3	-	-	12	-
West Asia and North Africa	49	18	-	28	-	1	1	2
South and East Asia	50	6	-	4	-	32	4	5
Latin America	20	43	11	-	18	1	6	-
All spring bread wheat	40	24	4	8	7	10	5	2
Spring durum wheat	19	37	-	27	12	-	6	-

[15] There are some minor discrepancies between targeted MEs and estimates of area planted in that ME, especially on a regional basis. These discrepancies may be simply errors, or may be the result of a variety being released by a second country that was actually targeted at a different ME in its country of original release.

This breakdown by ME was very similar with our earlier findings using the moisture regime classification, with the exception of the WANA region. The reason for the contrasting results for WANA is that 28% of the spring bread wheat releases in the region were targeted not only to ME 1 but also to the low rainfall, winter rain environment, ME 4A. But since ME 4A was often the second-mentioned targeted ME, we classified the associated varieties as targeted to ME 1.[16] Had we considered ME 4A as the main target environment for WANA, then the results would be consistent with earlier findings based on moisture regime classification for this region.

In spring durum wheat, there was less congruence between releases and area planted. MEs 1, 2, and 4B were targeted more often, and ME 4A less often, than would be indicated by areas. This is partially the result of multiple targeting (ME 1 or ME 2 as well as ME 4A in WANA), or, again, the relatively high rate of varietal release in Latin America (ME 4B).

Area estimates reported in Table 2.2 for winter and facultative bread wheat releases were more ambiguous than spring bread and spring durum releases. In particular, the breakdown between irrigated and high rainfall winter bread wheat in China is not clear. As a result, targeted ME information is not presented here. Across both winter and facultative bread wheat releases, releases by ME were roughly similar to the pattern of release by irrigated or well-watered versus dry environments (Table 3.1). However the proportion of facultative wheat releases targeted at dry environments (ME 9) seems to be larger than the share of facultative wheat area, perhaps as a result of a relatively high rate of releases in South Africa.

Releases by Semidwarf Character

In their study based on data collected in 1990, Byerlee and Moya (1993) calculated the percentage of varieties released by height (semidwarf or tall) and wheat type. Since South Africa and parts of China were not included in the 1990 study, we decided to re-estimate the percentage of semidwarf varieties released between 1966 and 1997. There was a rapid increase in the release of semidwarf varieties between 1966 and 1980, which is consistent with earlier findings of Byerlee and Moya (1993), particularly for spring bread and spring durum wheat (Figure 3.3). Since then, however, the rate of release of semidwarf varieties has slowed. The decrease in the numbers of semidwarf durum and winter wheat varieties released, as well as the slowdown in the rate of release of semidwarf spring bread wheat varieties between 1991 and 1997, seems to have resulted from continued release of some improved tall varieties for stressed environments. Most improved tall winter varieties released between 1991 and 1997 were released in South Africa or Turkey.

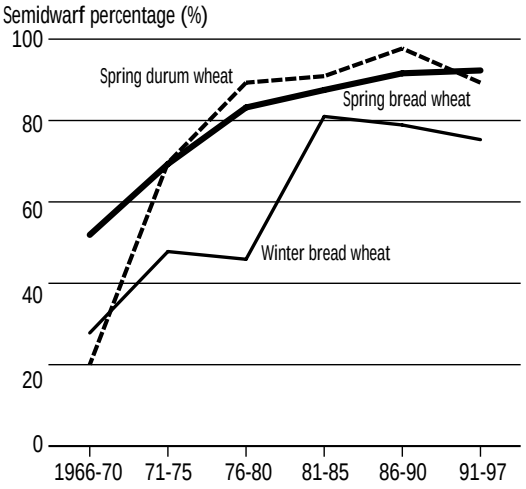

Figure 3.3. Percentage of all wheat releases that were semidwarfs, by wheat type, 1966-97.

[16] In general, there might be a bias towards lower-numbered ME's simply because they might tend to be the first mentioned, even if another ME is really a more important target for a given variety.

Origins of Varieties Released in Developing Countries

For this analysis, we classified varieties according to whether they were derived from a cross made by a national research program (Groups 1 and 2) or by CIMMYT (Groups 3 and 4). Our classification is very similar to that used by Byerlee and Moya (1993) except that varieties derived from a CIMMYT cross were divided into two separate groups:

1) Variety derived from a cross made by a national research program:
   - Cross that did not involve an immediate CIMMYT parent and that was made in the country in which the variety was released. This includes semidwarfs that have only CIMMYT grandparents or earlier ancestry.
   - Cross that did not involve an immediate CIMMYT parent and that was made in a country other than the country in which the variety was released.
2) Some CIMMYT germplasm—at least one parent from CIMMYT:
   - Cross that involved at least one parent from CIMMYT and that was made in the country in which the variety was released.
   - Cross that involved at least one parent from CIMMYT and that was made in a country other than the country in which the variety was released.
3) Cross made by CIMMYT, reselection made by NARSs.
4) Cross and selection made by CIMMYT.

In practice, available selection histories suggest that when NARSs make selections from CIMMYT crosses, they tend to make them in later generations.[17] As a result, in our analysis we combined categories 3 and 4 into a single category, "CIMMYT cross."

All countries surveyed have made considerable use of CIMMYT wheat germplasm. China differs from other countries, however, by using its own material to a great extent. The extent to which the Indian and Brazilian wheat improvement programs have made their own crosses is also notable, although a substantial amount of the breeding material in their research programs is based on CIMMYT germplasm (Traxler and Pingali 1998). In most other countries, the importance of CIMMYT crosses and CIMMYT parents has not changed since the 1990 study.

In the late 1960s, about one-third of all wheat varieties released by developing countries were CIMMYT crosses, and an additional one-sixth had at least one CIMMYT parent. By the 1990s, these fractions had risen to about one-half CIMMYT crosses and another one-quarter that had a CIMMYT parent. Throughout the period covered in this study, an additional 7-8% of releases could be traced to at least one CIMMYT ancestor.

Just under two-thirds of the spring bread wheat varieties released by developing countries in the 1960s had some CIMMYT content. Over the last 15 years, around 90% of the spring bread wheat releases had CIMMYT content. In the late 1970s, CIMMYT crosses as a percentage of spring bread wheat releases fell because more NARS releases were crosses with at least one CIMMYT parent. Since 1980, the percentage of spring bread wheat releases that are CIMMYT crosses has fluctuated narrowly around 50%. An additional 30% consisted of NARS crosses with at least one CIMMYT parent (Figure 3.4).

More than 76% of all wheat varieties released by national programs (including China) between 1991 and 1997 were spring bread wheats.[18] Of the more than 350 spring bread wheat varieties

[17] Byerlee and Moya (1993) did find some evidence that in an advanced program in Brazil, with which CIMMYT carried on a long-term shuttle breeding exchange, some selections were made from earlier generation, segregating material.

[18] Recall that nearly all spring bread wheats released today by NARSs in developing countries are semidwarfs.

released during this period, 53% were CIMMYT crosses, sometimes with reselection by NARS, 29% were NARS crosses with at least one CIMMYT parent, 8% were NARS crosses with CIMMYT ancestry, 7% were NARS semidwarfs with other ancestry, and 3% were tall varieties. The percentage of spring bread wheat releases that were CIMMYT crosses or had at least one CIMMYT parent was higher in 1991-97 (82%) than any other period, indicating that the use of CIMMYT germplasm has not declined in recent years (Figure 3.4).[19]

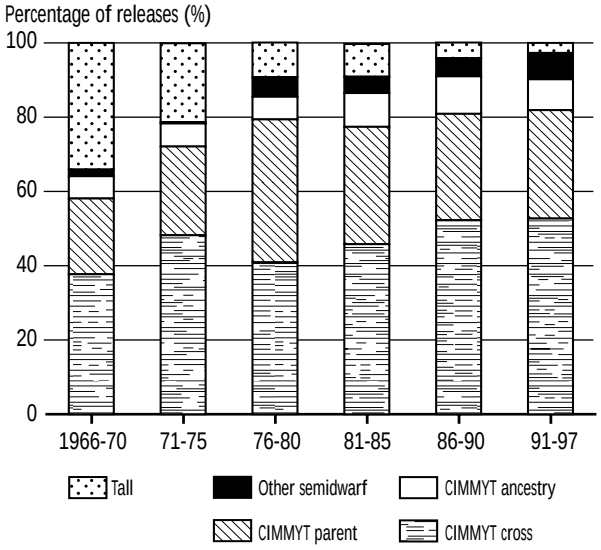

Figure 3.4. Spring bread wheat releases, developing world, 1966-97.

CIMMYT content in wheat releases differed by region. Over time, at least 80% of spring bread wheat releases in every major region had some CIMMYT ancestry. Asia (except for China and India) and the WANA region made particular use of CIMMYT crosses. China and India, the two largest wheat producers in the developing world, released proportionately more spring bread wheat varieties that were NARS crosses with at least one CIMMYT parent (Figure 3.5).

In the most recent period, 1991-97, virtually all spring bread wheat releases in Asia (not including China and India), WANA, and sub-Saharan Africa had some CIMMYT content. Moreover, CIMMYT crosses featured particularly heavily (62-73%) in releases in these regions. In India and Latin America, about 90% of spring bread wheat releases

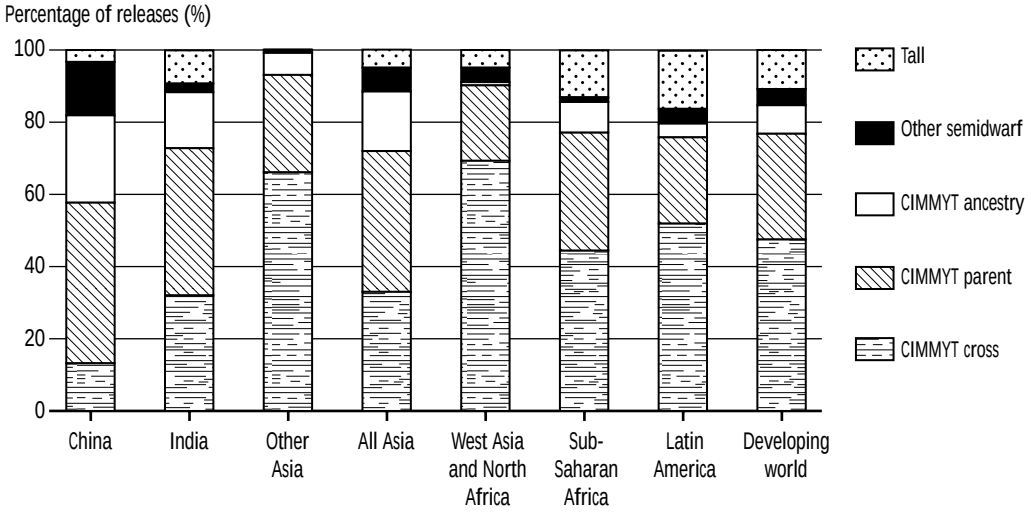

Figure 3.5. Spring bread wheat releases by region, 1966-97.

[19] Apparent discrepancies between the percentage of releases that are semidwarfs (Figure 3.3) and the release data by origin (Figures 3.4, 3.6, and 3.8) are caused by the fact that some varieties with CIMMYT parentage or earlier ancestry are not semidwarfs. This seems to be the case particularly for durum and winter/facultative types.

had some CIMMYT content in the 1990s, and about 50% were CIMMYT crosses. In contrast, in China, although 60% of spring bread wheat releases had some CIMMYT content in the 1990s (and the percentage was even higher in some earlier periods), no direct CIMMYT spring bread wheat crosses have been released in recent years (Appendix A, Table A.1).

Compared with spring bread wheats, a higher percentage of spring durum wheats released by NARS contained CIMMYT germplasm. Since the early 1970s, two-thirds to three-quarters of spring durum wheats released by developing countries have been CIMMYT crosses. Use of CIMMYT lines as parents for NARS crosses did not become common until the 1980s. By the 1990s, nearly all spring durum wheat releases had a CIMMYT ancestor. Between 1991 and 1997, 77% of more than 50 spring durum releases were CIMMYT crosses, 20% were NARS crosses with at least one CIMMYT parent, 2% were NARS crosses with known CIMMYT ancestry, and 2% were tall varieties without CIMMYT ancestry (Figure 3.6).

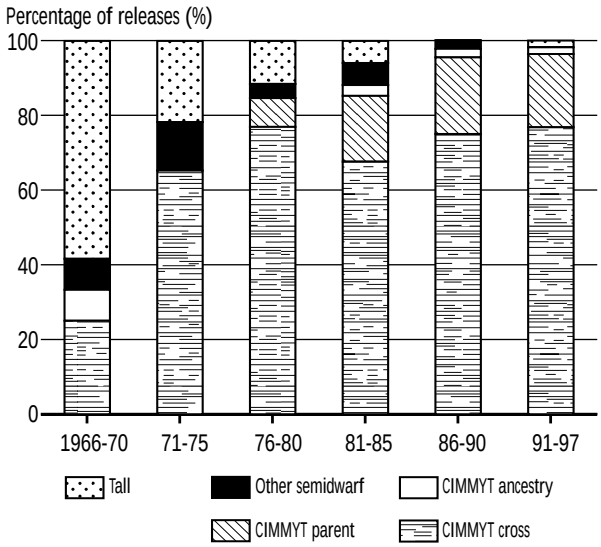

Figure 3.6. Spring durum wheat releases, developing world, 1966-97.

Spring durum releases based on CIMMYT crosses were important in all regions, but they were particularly predominant in WANA and Latin America. Spring durum wheat releases based on at least one CIMMYT parent were relatively common in sub-Saharan Africa, followed by India. Nearly 30% of spring durum releases in India were tall varieties, as were about 17% in sub-Saharan Africa (Figure 3.7; see also Appendix A, Table A.2).

In contrast, no winter wheat releases were direct CIMMYT crosses over much of the period covered by this study. Winter wheat varieties with some CIMMYT ancestry (cross, parent, or any ancestor)

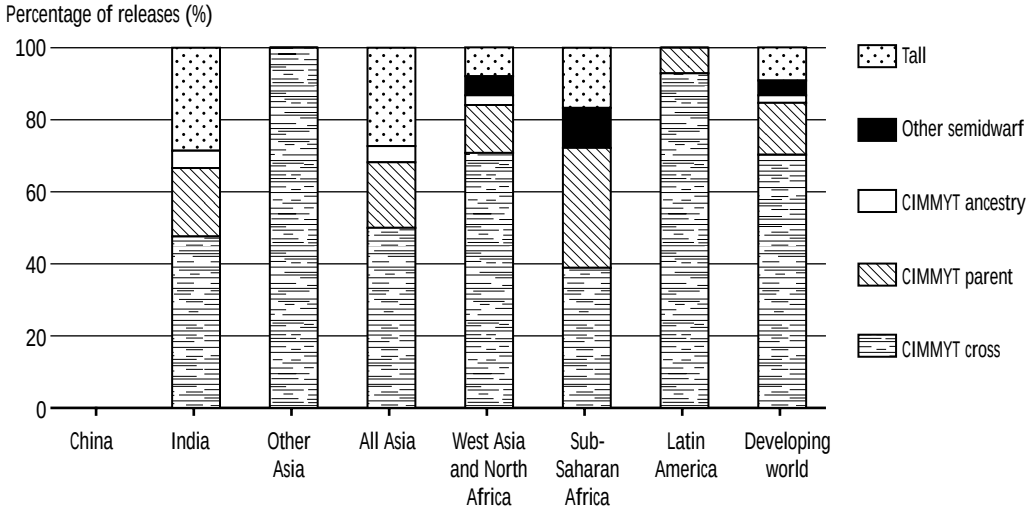

Figure 3.7. Spring durum wheat releases by region, 1966-97.

constituted about 35-40% of all releases since the 1970s. The number of winter bread wheat releases was considerably higher in 1991-97 (over 100) than earlier periods. The percentage of winter wheat releases that contained CIMMYT germplasm was also considerably higher in 1991-97 than previously. Following the opening of CIMMYT's collaborative winter wheat breeding program in Turkey in the mid-1980s, and the merging of this effort with ICARDA's highland wheat program in 1990, for the first time a notable percentage (15%) of winter wheat releases were based on direct CIMMYT crosses. Non-CIMMYT winter semidwarfs were mostly Chinese releases (Figure 3.8).

West Asia and North Africa had the highest percentage of winter wheat varieties with CIMMYT content between 1966 and 1997. Latin America, with relatively limited winter wheat area in the Southern Cone, also released a substantial proportion of varieties with CIMMYT content. As mentioned earlier, non-CIMMYT semidwarfs were predominant in China's winter wheat releases (Figure 3.9; see also Appendix A, Table A.3).

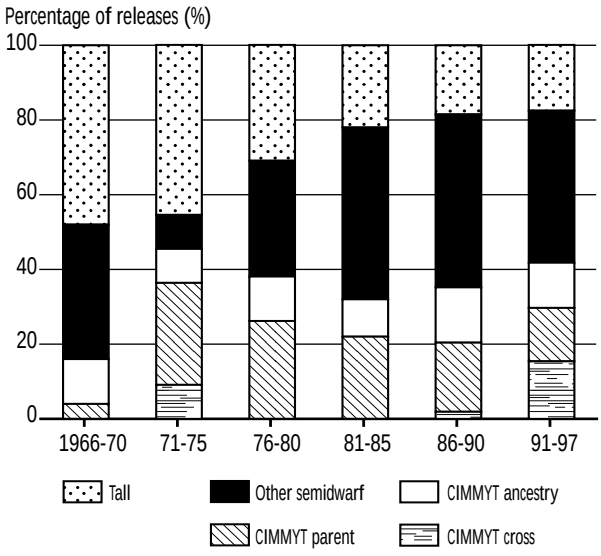

Figure 3.8. Winter bread wheat releases, developing world, 1966-97.

Private-Sector Wheat Releases and Wheat Varietal Protection in Developing Countries

Although the public sector dominates wheat improvement research in developing countries, there are some exceptions. Private-sector wheat improvement research has been strong in Argentina for some time. In 1935, Argentina was among the first countries in the world to institute some form of Plant Breeders' Rights (PBR) (Pray 1991). Argentina was also the first of the 36 study

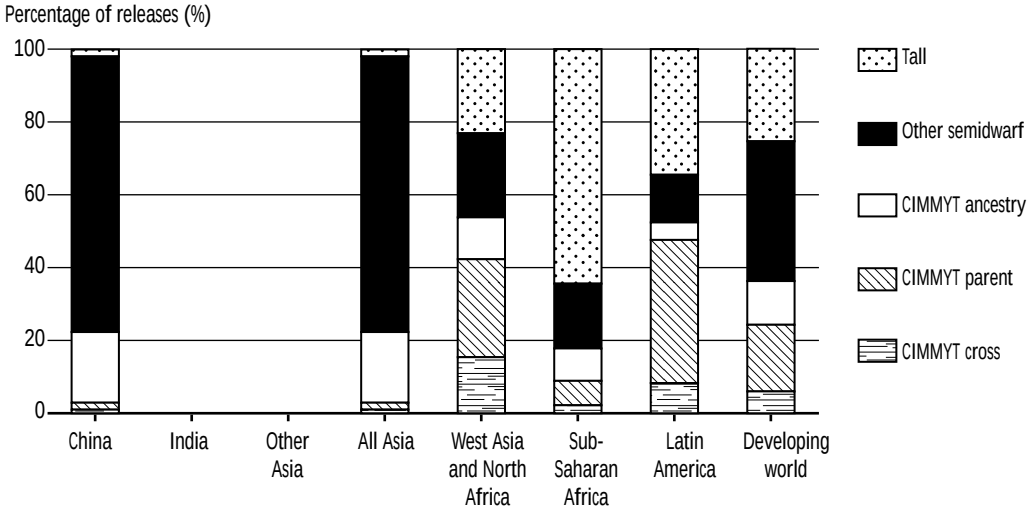

Figure 3.9. Winter bread wheat releases by region, 1966-97.

countries to become a member of the International Union for the Protection of New Varieties of Plants (UPOV). Varieties developed by the private sector in Argentina are sown in Brazil and Uruguay. Chile and Brazil have also conducted some private-sector wheat research. In Africa, the private sector currently appears to be important in South Africa and Zimbabwe (Heisey and Lantican 1999). Other African countries such as Kenya and Zambia, which had no private-sector wheat researchers in 1990, reported a modest level of private-sector research activity by 1997.

An increasing number of countries have joined the UPOV, an intergovernmental organization that was established by the International Convention for the Protection of New Varieties of Plants in 1961. The Convention aims to protect new plant varieties with intellectual property rights.[20]

As of September 1999, 12 of the 36 countries covered in this report were UPOV members: Argentina, Brazil, Bolivia, Chile, China, Colombia, Ecuador, Kenya, Mexico, Paraguay, South Africa, and Uruguay. Because most of these countries have only recently joined the UPOV, we were able to get the complete list of protected wheat varieties or varieties with PBRs for only five countries—Argentina, Brazil, Chile, South Africa, and Uruguay. To the extent possible, CIMMYT ancestry was traced for protected wheat varieties in these countries using CIMMYT's Wheat Pedigree Management System and our wheat impacts database. In general, pedigrees are less frequently available for private sector wheat varieties.

Figure 3.10 shows the percentage of protected wheat varieties with CIMMYT content in the five countries mentioned above. More than 60% of wheat varieties with PBRs in Argentina, Brazil, and Uruguay have CIMMYT content. Slightly less than 45% of Chile's protected wheat varieties are CIMMYT-related; varieties with unknown pedigrees account for more than 45%. Only 14% of protected wheat varieties in South Africa have known CIMMYT content; more than 50% have unknown pedigrees. Some of these unknown varieties may have CIMMYT ancestry, but because most of them are new varieties, it was not possible to get information on their pedigrees. Even though the figures presented come from only five countries, they indicate that protected or private-sector wheat varieties (these two categories are not always identical) in the developing world also make considerable use of CIMMYT germplasm.

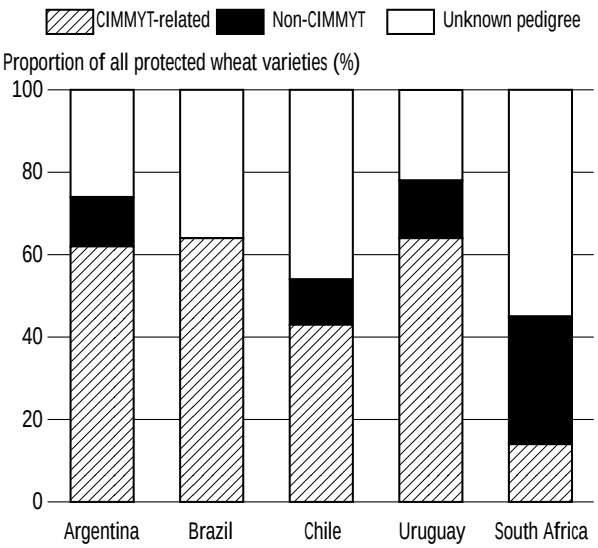

Figure 3.10. Parentage of protected wheat varieties, selected countries.

[20] For more details on the protection of new varieties under the international Convention, refer to UPOV's website (http://www.upov.int/eng/protectn/exclusive.htm).