CIMMYT

1993/94 World Maize Facts and Trends

Maize Seed Industries, Revisited: Emerging Roles of the Public and Private Sectors

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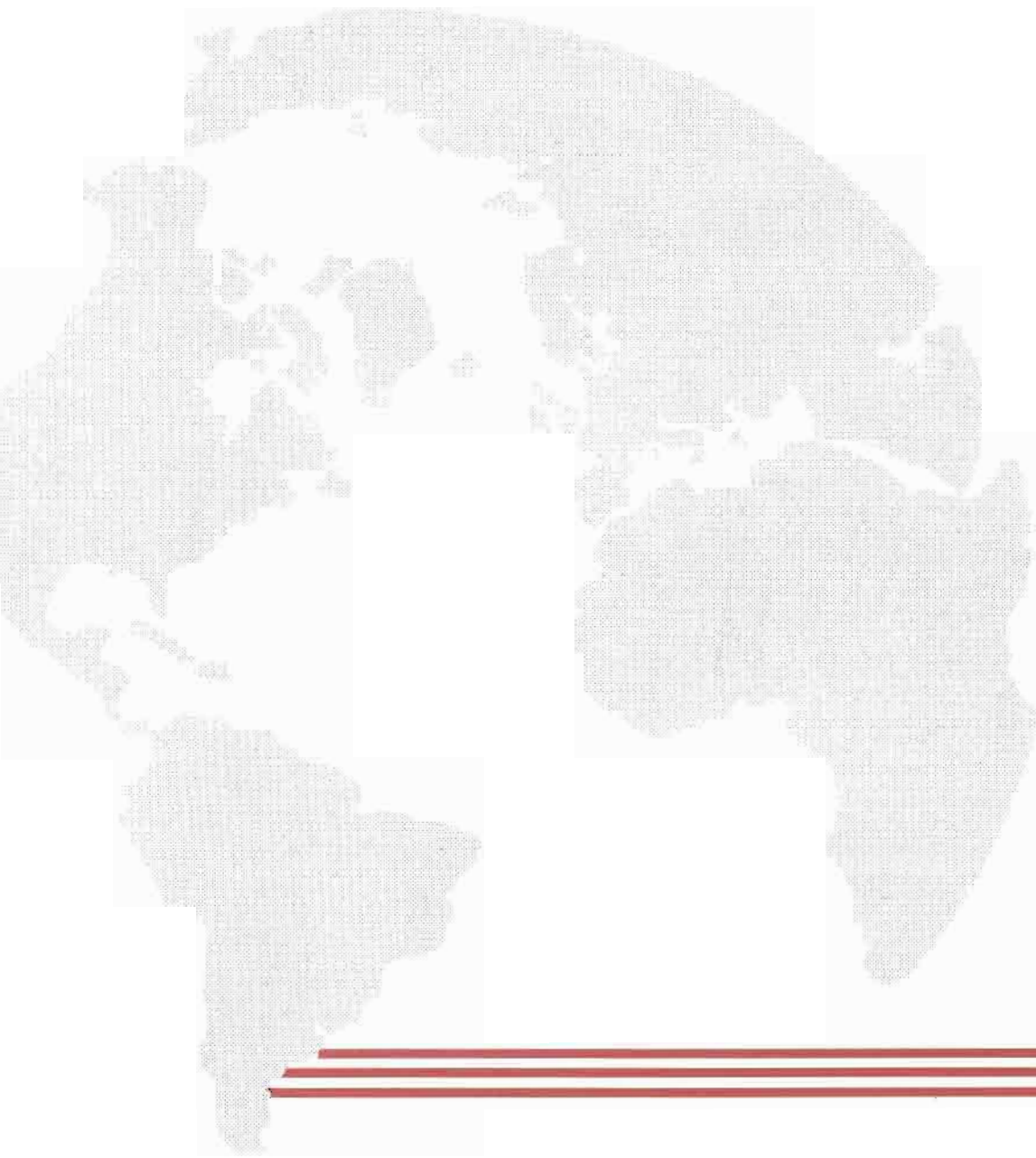


CIMMYT is an internationally funded, nonprofit scientific research and training organization. Headquartered in Mexico, the Center is engaged in a research program for maize, wheat, and triticale, with emphasis on improving the productivity of agricultural resources in developing countries. It is one of several nonprofit international agricultural research and training centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the International Bank for Reconstruction and Development (World Bank), and the United Nations Development Programme (UNDP). The CGIAR consists of some 40 donor countries, international and regional organizations, and private foundations.

CIMMYT receives core support through the CGIAR from a number of sources, including the international aid agencies of Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, India, Germany, Italy, Japan, Mexico, the Netherlands, Norway, the Philippines, Spain, Switzerland, the United Kingdom, and the USA, and from the European Union, Ford Foundation, Inter-American Development Bank, OPEC Fund for International Development, UNDP, and World Bank. CIMMYT also receives non-CGIAR extra-core support from the International Development Research Centre (IDRC) of Canada, the Rockefeller Foundation, and many of the core donors listed above.

Responsibility for this publication rests solely with CIMMYT.

Printed in Thailand.

Correct citation: CIMMYT. 1994. *CIMMYT 1993/94 World Maize Facts and Trends. Maize Seed Industries, Revisited: Emerging Roles of the Public and Private Sectors.* Mexico, D.F.: CIMMYT.
To cite Part 1: López-Pereira, M.A., and M.P. Filippello. 1994. *Maize Seed Industries, Revisited: Emerging Roles of the Public and Private Sectors.* Part I of *CIMMYT 1993/94 World Maize Facts and Trends. Maize Seed Industries, Revisited: Emerging Roles of the Public and Private Sectors.* Mexico, D.F.: CIMMYT.

ISSN: 0257-8743
ISBN: 968-6923-28-4
AGROVOC descriptors: Zea mays, seed industry, seed production, public enterprises, private firms, marketing, economic analysis, developing countries
AGRIS category codes: E21, F03
Dewey decimal classification: 338.17315

Contents

Abstract

This report analyzes interactions between public and private sector organizations in the world maize seed industry, with emphasis on the developing world. The analysis includes the share of total maize seed sales in 1992 by different kinds of seed enterprises and by different types of seed (hybrids, open pollinated varieties) and its origin (public or private sector breeding programs). Since the mid-1980s, private organizations in most developing countries have maintained and strengthened their position as the major producers and distributors of maize seed, while maize seed production and distribution by the public sector have tended to diminish. However, public breeding systems are still very important in maize seed industries; more than 50% of all the seed sold in developing countries in 1992 was of public origin. Over the next 10-20 years, the developing world seed industry will continue to evolve towards stronger public-private sector collaboration. Although schemes for direct production and distribution of maize seed by the public sector are largely a thing of the past, public breeding systems will remain important for fostering the development of domestic private seed enterprises and small-scale seed producers, and conducting research directed at small-scale farmers.

Acknowledgments

Many of the issues discussed in this report were analyzed earlier by Jim Longmire in a 1986 study of commercial maize seed production in developing countries (CIMMYT 1987). The authors are indebted to him for providing a thought-provoking and well-researched point of departure for the present report.

This issue of *World Maize Facts and Trends* was developed under the guidance of Miguel A. López-Pereira. He coauthored Parts 1 and 2 of the report with Michael Filippello, who also prepared the statistical tables in Part 3. Laura Saad contributed to Part 2 of the report. The publication was designed by Miguel Mellado E. and edited by Kelly Cassaday. Valairat Kuslasayanon oversaw publishing and distribution of this report in Thailand.

The authors are grateful to many colleagues who took the time to provide the information used in this *Facts and Trends*: A.O. Akintunde, Recai Akman, Hassan Al-Ahmmad, Mohammad Aslam, Gonzalo Avila, Nenita Baldo, David Beck, Khadija Benahnia, Murat Bengi, Benti Tolessa, Angelo Bianchi, Calisto Bias, George Bigirwa, Cesar Antonio Boza Miranda, Luis Brizuela, Iveta Capková-Rothová, Orlando Carrillo, Mario Caviedes, Chen Zehui, Chen Zong-Long, Ntji Coulibaly, Toma Dankov, William Dar, Fernando J. de Almeida, M. Derieux, Martin D. Escobar, Alejandro Espinosa, Guillermo Eyherabide, Alberto Fassio, Yallou Chabi Gouro, Fidencio Antonio Guerra, Gengchen Han, Jorge Huezo, Hema Idrissa, A.A. Ismail, Celtus Janni, Kevin Kimle, Attiey Koffi, Luis Macagno, Cecilio Marcos Torres, Esseh-Yovo Mawule, S.B. McCarter, Helmut Messner, Y. Montalant, Lieketso Moremoholo, Jesús Moreno, L. Mose, Alfred Moshi, K. Mtinde, Catherine Mungoma, Alejandro Navas, Luis A. Narro León, Abdou Ndiaye, Emmanuel Ndoruhirwe, Rafael Obando, Guillermo Ortiz Ferrara, Manuel Oyervides, Orlando Paratori, Mahesh Man Palikhe, F.M. Quinn, Emmanuel Rufyikiri, Joseph Rusike, Félix San Vicente, Rodrigo Sbarbaro, J.A. Schillinger, Narongsak Senanarong, Dine Seyfoulaye, John Sfakianakis, N.N. Singh, Subandi, Tomás Szundy, Charles Thé, Nicola Tomov, Ching T. Tseng, M. Tsiu, Roger Urbina, Tran Hong Uy, P.P. Van der Walt, Deon Van Rooyen, W.H. Verburgt, Rubén Verges, José Alberto Yau Quintero, Roberto Zavaca, Zhang Shi-Huang, and staff of the Kenya Agricultural Research Institute.

Many CIMMYT staff also assisted with data collection: Jorge Bolaños, Carlos de León, Alpha O. Diallo, Catherine Giauffret, Rashid Hassan, Paul Heisey, David Jewell, Michael Morris, Wilfred Mwangi, Shivaji Pandey, Kevin Pixley, Joel Ransom, Gustavo Sain, and Robert Tripp. Their untiring efforts are much appreciated.

Finally, this issue of *Facts and Trends* benefited from the technical and editorial counsel of numerous reviewers, including Derek Byerlee, Hugo Córdova, Elizabeth Cromwell, Carlos de León, Alpha O. Diallo, Donald Duvick, Rubén Echeverría, Diego González de León, Larry Harrington, Paul Heisey, Delbert Hess, David Jewell, Jim Longmire, Ricardo Magnavaca, Michael Morris, Wilfred Mwangi, Ripusudan Paliwal, Shivaji Pandey, Carl Pray, Roger Rowe, Joseph Rusike, Gustavo Sain, N.N. Singh, Melinda Smale, Robert Tripp, Sam Vasal, Richard Wedderburn, and Donald Winkelmann.

Foreword

In the *1986 World Maize Facts and Trends*, we described the workings of the developing world's maize seed industry for our readers, raising "one central question," which was "the extent to which public organizations, private organizations, or both should . . . operate in developing countries." The question was far from rhetorical, given the growing concern over the performance of the public sector in providing seed to farmers, and we certainly were not the only ones seeking an answer.

The question of who should participate in the seed industry has continued to occupy the attention of policy makers in many countries. Largely as a result of the trend toward privatization in all sectors of the economy, governments have taken an increasingly positive stance toward the private sector's participation in the seed industry. Throughout the world, seed laws have become less restrictive. Private companies in many instances are no longer barred from producing and selling seed of varieties developed by public breeding programs. Importing seed has become easier, and the process for registering and releasing varieties is faster. It is not surprising that new, more flexible arrangements for developing, producing, and selling seed have followed on these changes. But another outcome of these changes is uncertainty over roles and responsibilities, and the public sector in particular must confront a host of new issues about its future role in the maize seed industry.

Clearly private and public organizations in the seed industries of many countries have reached a crucial juncture, for much of their future effectiveness will depend on the kinds of working arrangements they choose to develop now. CIMMYT and national agricultural research programs are especially concerned with understanding the trends that will influence these choices, for the development of efficient seed industries is essential for providing more — and a wider variety — of improved maize seed to farmers at affordable prices. An important objective of this report is therefore to present a clearer view of the activities of the public and private sectors in the maize seed industries of developing countries. We provide new information on maize seed industries in a number of countries, as well as data on the extent to which farmers in the developing world use improved maize seed. We anticipate that this information will assist institutions in assessing their roles in the seed industry and will also serve as a baseline for other studies of maize seed industries in developing countries, especially the share of public and private organizations in seed production and the origin of the seed sold in different regions and countries.

It is important to note at the outset that the issue is not to decide whether the public or private sector should retain control over all phases of the maize seed industry. On the contrary, either public or private institutions may be active in any phase of the industry, from research and development to seed production and marketing. The real issue is to describe roles these institutions might play in the seed industry as it develops. Another point that requires clarification is that "the private seed industry" does not mean only "large seed companies." The reality is rather different: there is an extreme diversity of actors in the seed industry, extending from large multinational firms to non-governmental organizations and very small farmer/seed producers, and the public sector is also sometimes made up of various elements.

Each of these varied entities may require different products and working relationships with one another. Clearly there will be no single, ideal model for the seed industry. Each country must develop the appropriate combination of institutions to fit its stage of development, market size, types of farmers, and maize growing environments. Likewise, governments will need to be sensitive to demands by these different institutions and develop appropriate policies on, among other things, intellectual property rights, seed imports, varietal release, credit, and, at times, training for private companies.

No-one can predict the future shape of the maize seed industry, given that the environment in which private and public institutions function is still changing rapidly with respect to technical issues, legal issues, and (for the public sector) funding levels. However, the kinds of institutions that emerge will depend in large measure on the goals they seek to achieve. We have assumed that common goals include a greater choice of healthy maize seed for farmers and affordable seed prices. Our readers are encouraged to bear this in mind as they examine our conclusions in the pages that follow.

Donald L. Winkelmann
Director General, CIMMYT

Part 1

Maize Seed Industries, Revisited: Emerging Roles of the Public and Private Sectors

Miguel A. López-Pereira and Michael P. Filippello

Introduction

Nearly a decade ago, the *CIMMYT World Maize Facts and Trends* (CIMMYT 1987) examined the economics of commercial maize seed production in developing countries, focusing on the costs of producing different types of improved maize seed and on the requirements for establishing viable seed industries. In the intervening years, institutional arrangements for producing maize seed have become increasingly varied as the rules governing private sector participation in the seed industry have changed. In some cases, private seed companies can now market seed without having to go through the formal seed certification process; in others, private companies are no longer restricted from producing and selling seed developed by public breeding agencies.

It is no longer unusual to find individual seed producers, local seed cooperatives, non-governmental organizations (NGOs), and national and multinational private enterprises coexisting with public sector research and seed enterprises in developing countries. Growing doubt about the role of the public sector in agricultural development in general, and the seed industry in particular, has made national governments and donor agencies less disposed to support seed production by the public sector. At the same time, great faith has been placed in the private sector's ability to provide maize seed to farmers. To obtain a more accurate idea of the implications of these changes in the maize seed industry and develop a baseline for future studies, we have assembled information from a number of sources (see the box, "Sources of Information for This Report," page 3), including a survey of maize seed industries worldwide. Our report begins with a discussion of how maize seed industries function, providing information on public and private sector investment in maize breeding and seed production in developing and industrialized countries. We then turn our attention to the clients of the seed industry, examining farmers' use of improved maize seed, the value of the seed sown by farmers, and commercial seed sales. Next, we analyze the economics of maize seed supply and adoption with a view to understanding which economic and institutional conditions enable maize seed industries to succeed in providing improved seed to farmers. Like its predecessor, this report concludes with a look at the circumstances likely to influence the world maize seed industry in the coming decades.[1]

How the World Maize Seed Industry is Organized

Providing maize seed for sale to farmers is the culmination of a lengthy process in which many different actors participate. This process can be divided into three broad phases: 1) research and development (R&D), 2) seed production and conditioning, and 3) marketing and distribution. Because these phases are highly interdependent, the effectiveness of the activities performed in one phase depends very much on the effectiveness of the activities performed in the others. Private or public organizations can be active in any phase of this process, from basic research to seed distribution.

The Objective and Functions of the Commercial Maize Seed Industry

In principle, the maize seed industry has one primary objective: to provide high quality seed to maize farmers in a way that gives an appropriate return on investment. Figure 1 depicts the flows of breeding material to and from public and private sector organizations and their clients. Local maize varieties and land races are part of the genetic reservoir that public and private breeding organizations draw upon to develop new open pollinated varieties (OPVs) and hybrids. These improved materials are tested and subjected to a varietal release process. After a variety is approved for release, seed can be produced and conditioned[2] for distribution to farmers.

Each of these functions can be performed by different actors. Which actors are involved and the functions they perform depend mainly on the degree of development of the industry. *International agricultural research*

[1] Readers interested in a more comprehensive analysis of these issues should consult the CIMMYT Economics Working Paper by López-Pereira and Filippello, *Emerging Roles of the Public and Private Sectors of Maize Seed Industries in the Developing World* (forthcoming, 1994).

[2] Seed conditioning involves several processes, including drying, cleaning, and chemical treatment.

centers (IARCs), such as CIMMYT and the International Institute of Tropical Agriculture (IITA), develop basic, non-commercial maize germplasm products, including improved populations, OPVs, and inbred lines, which are available to public and private research organizations free of charge (see the box, "CIMMYT and the World Maize Seed Industry," page 5). *Public national agricultural research systems* (NARSs) often combine materials from the IARCs with local materials, selecting varieties and hybrids for local release after extensive evaluation. The NARSs may offer germplasm to private organizations for a fee and/or produce and distribute commercial maize seed directly through public seed companies. *Multinational seed companies* usually develop their own (proprietary) hybrids, and commercial seed of these hybrids is usually produced by the multinational or by *private national companies* under contract, subject to royalty agreements. Private national companies may also produce their own materials or use materials developed by the public research system. *Seed cooperatives, NGOs,* and *individual farmer-seed producers* also produce improved seed developed by public sector organizations, for sale mostly to small-scale farmers.[3]

The various groups interacting in the maize seed industry are described in greater detail in the paragraphs that follow. Although the discussion focuses mostly on organizations involved in commercial maize seed production, the reader should bear in mind that large numbers of farmers in the developing world produce their own maize seed and thus are an important part of the seed industry. In fact, in many countries this kind of informal maize seed production and exchange is more important than formal maize seed enterprises.

Who Produces Commercial Maize Seed?

Public sector breeding programs and seed companies — This group of seed producers includes one or more breeding institutes and/or one or more parastatal seed companies that produce and distribute seed under the aegis of the public NARS in a given country. Although public sector seed companies normally produce and distribute seed of materials developed by public breeding organizations, in most cases breeding and seed production/distribution are done by separate entities within the system. Public breeding programs may also make their improved germplasm available to private organizations, either for further breeding or for direct seed production and distribution; private companies may or may not be charged for this service.

Traditionally, public seed companies were a significant presence in the maize seed industries of many developing countries, but, as demonstrated later in this report, this situation is changing and public NARSs increasingly concentrate on maize R&D. Public sector organizations also appear to have become less important in the seed certification process, limiting themselves to testing and providing information on their own materials and those of the private sector.

The IARCs are also public research organizations. The scope of their breeding research is international and they do not engage in commercial seed production.

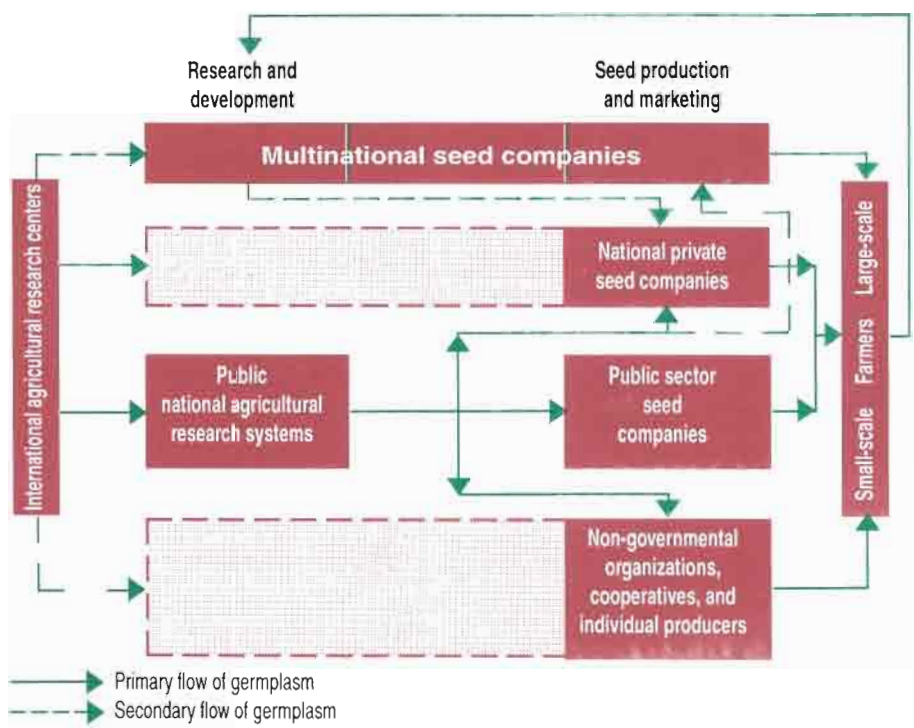


Figure 1. Framework for viewing public and private sector interactions in the maize seed industry.
Source: Adapted from Byerlee, Morris, and López-Pereira (1993).

[3] NGOs are considered "non-public" institutions rather than "private" ones. Although they generally do not depend *directly* on public funds to operate, NGOs are distinct from private companies in that they do not seek to make a profit. For simplicity's sake we refer to them together with private institutions such as seed cooperatives, but the reader should be aware that NGOs are in a class by themselves.

Multinational seed companies — Multinational seed companies, which operate in more than one country, usually maintain their headquarters in industrialized countries; their breeding and/or seed production and distribution operations in developing countries are either wholly owned subsidiaries or joint ventures with national companies. The multinationals' activities in developing countries range from simply importing maize seed to operating comprehensive seed enterprises with sophisticated breeding programs and the capacity to market locally produced seed.

Private national seed companies — Private national seed companies are companies with majority ownership by local individuals or organizations. They have long been active in the seed industries of developing countries and have been the main beneficiaries of the changes in policies governing maize seed industries. With few exceptions, most private national seed enterprises limit themselves to producing and distributing seed of maize materials developed by public sector breeding programs. However, some private national companies have their own breeding programs. These organizations often can operate effectively in markets that are too small to interest multinational companies.

Other types of seed producers — Several kinds of organizations produce and sell maize seed but are not included in the categories described above: seed producers' cooperatives, NGOs, and individual farmers who produce maize seed for sale. They often perform the important function of distributing seed to specific groups of farmers, such as the members of cooperatives, or to farmers in more isolated or marginal areas. Their activities thus complement those of more formal seed enterprises. Recently NGOs have been instrumental in providing seed to farmers in countries where, because of extraordinary circumstances — war, natural disasters — the more formal seed system is ineffective. With a few notable exceptions, these "less formal" seed producers have no breeding programs.[4]

Industry Structure and Level of Investment in Maize Research

The CIMMYT survey elicited considerable information on the structure of maize seed industries and levels of maize research investment throughout the world. The 51 developing countries that supplied data (Annex 1) support 245 public research stations that have maize breeding responsibilities. More than 40% of these stations are located in Asia (Table 1). In 1992, three of every four maize breeders in the developing world (excluding China) worked in the public sector. The greatest number of private sector breeders is found in Latin America; sub-Saharan Africa has the fewest. These proportions change completely in industrialized countries, where 80% of all maize breeders work in the private sector.

The types and numbers of maize seed companies vary substantially across regions (Table 2). Public sector seed companies are still fairly numerous in the developing world, although their participation in the seed market is small. Many of these enterprises may be idle or underutilized, but their presence indicates that public sector

Sources of Information for This Report

This report draws heavily on data gathered through CIMMYT's Maize Seed Industry Survey in 1993. The 51 developing and 11 industrialized countries responding to the survey (an 87% return rate) account for 89% of the world's maize area, 95% in developing countries and 79% in industrialized countries (Annex 1 lists countries responding to the survey). Several countries in Eastern Europe and the former Soviet Union could not respond to the survey, but data on the most important maize-producing countries in Eastern Europe were available from previous CIMMYT surveys (however, these data should be interpreted with caution).

The data reported here thus offer a representative view of maize seed industries in each region of the world. They are the best estimates available on maize seed industries in developing countries, and are generally based on official data (most survey respondents were leaders of public maize research organizations). The survey data are supplemented by data from other studies of the economics of improved maize seed production and use in developing countries. The reader is referred to López-Pereira and Filippello (forthcoming, 1994); Byerlee and López-Pereira (1994); López-Pereira and García (1994); López-Pereira and Morris (1994); Byerlee, Morris, and López-Pereira (1993); López Pereira and Espinosa (1993); and CIMMYT (1987) for more details. Related studies include Douglas (1980); Pray and Ramaswami (1991); Sharanjit and Douglas (1992); Cromwell, Friis-Hansen, and Turner (1992); and Jaffee and Srivastava (1994).

[4] Exceptions include several cooperatives in Brazil, which serve large-scale farmers, and the Seed Co-op of Zimbabwe, which has a breeding program, serves large-, medium-, and small-scale maize farmers, and exports seed to neighboring countries.

divestiture from the seed business is not yet complete in many developing countries. The greatest concentration of public sector seed companies clearly is in China, followed by sub-Saharan Africa. National and multinational seed companies have a stronger presence in Asia (China excluded) and Latin America, where private maize seed sectors are better developed, than in other regions. The number of "other" seed organizations (cooperatives, NGOs, and individual seed producers) matches or surpasses the totals of the other three categories.[5]

The number of maize breeders per thousand tons of maize seed sales is high in West Asia and North Africa and Asia (again, excluding China) and low in sub-Saharan Africa and Latin America (Table 3). The relatively high number of maize breeders in Asia appears to be related to the large numbers of provincial research stations and seed enterprises in Asian countries, which must be staffed with breeders even though total seed production in a given province may be low. (However, among developing countries, China has the fewest breeders per thousand tons of seed sales.) For both developing and industrialized countries, there is about one breeder per thousand tons of seed sales.

Table 1. Public maize research stations and numbers of public and private sector maize breeders in the world, 1992

Region	Number of public research stations conducting maize improvement research	Number of maize breeders		
		Public sector	Private sector	Total
Sub-Saharan Africa	42	95	23	118
West Asia and North Africa	24	93	27	120
Asia, less China	51	220	107	327
China	55	440	0	440
Latin America	73	224	148	372
All developing countries	245	1,072	305	1,377
All developing countries, less China	190	632	305	937
Industrialized countries	82	214	800	1,014
World	**327**	**1,286**	**1,105**	**2,391**

Source: CIMMYT 1993 Maize Seed Industry Survey.
Note: Includes data from 51 developing and 11 industrialized countries.

Table 2. Structure of the world maize seed industry by type of company, 1992

Region	Number of countries in each region	Number of seed companies				
		Multi-national[a]	Private national	Other non-public[b]	Public	Total
Sub-Saharan Africa	20	13	12	164	63	252
West Asia and North Africa	4	8	45	1	6	60
Asia, less China	9	20	208	597	41	866
China	1	0	0	0	24	24
Latin America	18	40	114	175	37	366
All developing countries	51	81	379	937	171	1,568
All developing countries, less China	50	81	379	937	147	1,544
Industrialized countries	11	76	362	94	34	566
World	**62**	**157**	**741**	**1,031**	**205**	**2,134**

Source: CIMMYT 1993 Maize Seed Industry Survey.
Note: Includes data from 51 developing and 11 industrialized countries.
[a] Multinationals that operate in several countries are counted as individual companies in each country.
[b] Includes NGOs, producers' cooperatives, and individual seed producers.

Farmers' Use of Improved Maize Seed

The preceding discussion of the structure and function of the maize seed industry has told only half of the seed production story. The other half, told below, lies with the farmers who actually use the seed.

Maize Growing Environments

Virtually all maize in industrialized countries is grown in temperate environments. In contrast, the main growing environments for maize in developing countries are the tropical lowlands, tropical mid-altitudes, and the subtropics. Only about 25% of the maize area in developing countries is located in temperate environments, virtually all of it in a few countries, notably China and Argentina. Although breeding techniques can and have been transferred from temperate to non-temperate regions, differences in growing conditions make it difficult to transfer improved germplasm directly from temperate to non-temperate environments. Differences in growing environments and in the use of

[5] It should be noted that this group includes some seed organizations that only distribute seed, as opposed to producing and distributing it. This may especially be the case for NGOs.

improved technologies, including improved seed, are reflected in differences in yields in developing and industrialized countries and among developing countries. Average maize yields in developing countries (excluding China, Argentina, and Brazil)[6] are less than 2 t/ha, compared to more than 6 t/ha in industrialized countries.

Trends in Maize Area and Farmers' Use of Improved Maize Seed

Worldwide, the area planted to improved maize seed rose by about 4 million hectares between 1985 (the time of the previous maize seed industry survey) and 1992 (Table 4). All of these gains occurred in developing countries, where the total maize area estimated to be planted to improved seed grew from 37 million hectares in 1985 to 49 million hectares in 1992, raising the area under improved maize seed from 45% to 58%. In industrialized countries, maize area declined by around 8 million hectares. Since nearly all the maize produced in these countries comes from improved seed, the reduction in area translated into a reduction in the area planted to improved seed, which fell from 56 million hectares to 48 million hectares.

Table 3. Maize breeders per thousand tons of seed sales, 1992

Region	Breeders per thousand tons of seed sales[a]
Sub-Saharan Africa	1.3
West Asia and North Africa	7.8
Asia, less China	4.1
China	0.6
Latin America	1.6
All developing countries	1.2
Developing countries, less China	2.2
Industrialized countries	1.3
World	1.3

Source: CIMMYT 1993 Maize Seed Industry Survey.
Note: Includes data from 51 developing and 11 industrialized countries.
[a] Breeders per 1000 t of all seed sales in region.

The area planted to improved maize seed in 1992 was divided equally between developing and industrialized countries. There were 30 million hectares of maize under improved seed in China, Brazil, and Argentina, compared to 19 million hectares in all other developing countries. Within the latter group, improved maize area is distributed nearly equally among Africa (6 million hectares), Asia (7 million), and Latin America (5 million). The area planted to local maize and other non-commercial seed in developing countries was still large in 1992, totaling 35 million hectares. Increasing maize productivity in many of these areas (for example, through the use of improved seed) remains a fundamental challenge for maize researchers and seed enterprises in the developing world.

CIMMYT and the World Maize Seed Industry

The CIMMYT Maize Program seeks to help the poor in developing countries by increasing the productivity of resources committed to maize, while protecting natural resources. This objective is accomplished through the preservation, improvement, and dissemination of genetic resources; the development of environmentally compatible crop management practices; the provision of research methodologies and information; and through training and consulting (CIMMYT Maize Program 1994). The Program targets its work to tropical and subtropical environments, where the vast majority of the world's poor maize farmers live, and focuses on developing improved materials possessing high yield potential, good agronomic characteristics, and resistance/tolerance to important diseases and pests. Other breeding programs use these products to develop their own finished varieties, or they release them directly; CIMMYT does not release commercial varieties.

CIMMYT's products are used most widely by public national agricultural research systems in developing countries, which are the Center's main partners in research. Between 1966, when the Center was founded, and 1990, the national research systems of developing countries released 842 maize varieties and hybrids. More than half (445) of these varieties carried CIMMYT germplasm (López-Pereira and Morris 1994). Most of the CIMMYT-derived materials (75%) had been further improved by NARS breeders before their release, indicating the considerable collaboration between international agricultural research centers and national breeding programs. Private seed organizations can also make use of the Center's germplasm in their breeding programs.

Breeding programs obtain CIMMYT germplasm through two principal channels. First, international trials are sent to national program collaborators throughout the developing world, providing them with an opportunity to evaluate experimental germplasm. If they choose to do so, the collaborators may request seed of promising materials. Second, seed is shipped to maize breeders in national programs and private seed organizations on request. Once in the hands of the recipients, CIMMYT germplasm may undergo further improvement in their breeding programs or may be released directly as official varieties.

[6] Maize production differs substantially in these three countries compared to other developing countries. In China, more than 80% of the maize area is located in temperate environments, the use of single-cross hybrid seed is almost universal, maize is used mainly as an animal feed (see Part 2), and the maize seed industry is dominated by the public sector. In Argentina and Brazil (except northeastern Brazil), maize is a commercial crop produced on medium- to large-scale farms where hybrid seed and purchased inputs are used. The private sector dominates the maize seed industries of these two countries. Because of these differences, this report presents data on the maize seed industry with and without China, Argentina, and/or Brazil as appropriate.

Table 4. Maize area by type of seed used, 1985 and 1992

	Maize area (million ha)	Maize area under improved seed (million ha)	Percent of maize area under		
			Local materials	Open pollinated varieties	Hybrids
1985					
All developing countries	81	37	55	7	38
Argentina, Brazil, China	32	24	28	1	71
Other developing countries	49	13	73	11	16
Industrialized countries	57	56	2	0	98
World	**138**	**93**	**33**	**4**	**63**
1992					
All developing countries	84	49	42	15	43
Argentina, Brazil, China	37	30	18	9	73
Other developing countries	47	19	61	20	19
Industrialized countries	48	48	1	0	99
World	**133**	**97**	**27**	**10**	**63**

Source: CIMMYT Maize Facts and Trends Survey, 1986, and CIMMYT 1993 Maize Seed Industry Survey.
Note: Totals may not add exactly due to rounding.

Table 5. Maize seed used in the world, 1992

Seed type	Developing countries (000 t seed)	Industrialized countries (000 t seed)	Total by type of seed (000 t seed)
Local varieties	1,051	8	1,059
Recycled open pollinated varieties[a]	264	0	264
Commercial open pollinated varieties	118	3	121
Hybrids	1,022	960	1,982
Total	**2,454**	**971**	**3,425**
Commercial seed[b]	1,140	963	2,103
(share of total)	(46%)	(99%)	(61%)

Source: CIMMYT 1993 Maize Seed Industry Survey.
a "Recycled" seed is saved from the maize harvest for planting in the subsequent cropping season.
b Sum of commercial open pollinated varieties and hybrid seed.

Table 6. Commercial maize seed sales and value of seed used, 1985 and 1992

	Developing countries	Industrialized countries	World[a]
Total commercial seed used		(000 t)	
1985	901	1,011	1,912
1992	1,140	963	2,103
Total value of commercial seed		(million $)[b]	
1985	587	2,695	3,282
1992	850	3,578	4,428
Change from 1985 to 1992		(%)	
Commercial seed	+27	-5	+10
Value of commercial seed	+44	+33	+35

Source: CIMMYT Maize Facts and Trends Survey, 1986, and CIMMYT 1993 Maize Seed Industry Survey.
a Includes countries not participating in the seed industry survey.
b Constant 1992 US dollars.

Total Maize Seed Used and Its Value

The five-million-hectare decline in world maize area between 1985 and 1992 did not reduce the total amount of maize seed used. The reduction in seed use in industrialized countries was more than offset by substantial increases in developing countries. Farmers in developing countries used 2.5 million tons of maize seed in 1992, including commercial seed and seed produced for their own use, for an average seeding rate of 29 kg/ha. This compares to 1 million tons of seed sown by farmers in industrialized countries and an average seeding rate of 20 kg/ha. Commercial seed (hybrids and OPVs) accounted for 46% of the seed used in developing countries, compared to virtually 100% of the seed used in industrialized countries (Table 5).

Of the 3.4 million tons of maize seed used globally in 1992, 2.1 million tons were sold as commercial seed, 94% of it hybrid seed. This commercial seed was valued at US$ 4.4 billion (Table 6),[7] which was 35% higher (in real prices) than the value of commercial seed sold in 1985. If we include the seed produced by farmers for their own use (local varieties, recycled OPVs,[8] and advanced generation hybrid seed), the total value of seed used in 1992 was US$ 4.7 billion.

One country — China — accounts for 21% of the commercial OPV seed and over two-thirds of the hybrid seed sold in developing countries. Commercial seed sales by all other developing countries total 89,000 t of OPVs and 332,000 t of hybrid seed. Overall, hybrid

7 All monetary figures are in constant 1992 US dollars.

8 "Recycled" seed is saved from the maize harvest for planting in the subsequent cropping season. Farmers may choose to recycle seed for many years rather than purchase fresh commercial maize seed.

seed comprises 90% of the seed sales in developing countries (79% when China is excluded) (Table 7). When China is excluded from the analysis, Asia is the region among developing countries where the OPV market share is highest and where more OPV seed is sold. After Asia, sub-Saharan Africa has the highest OPV market share, while Latin America, with its larger overall market, sells more OPV seed.

Shares of Commercial Seed Sales

Commercial OPVs — Public sector companies sold 48% of all commercial OPV seed purchased in 1992 in the developing world (34%, excluding China) (Table 8). Private national companies, NGOs, cooperatives, and individual seed producers accounted for 41% of all OPV sales (52%, excluding China). Thus commercial OPV seed is produced and distributed mainly by national seed companies, public and private. Sales of OPV seed by multinational companies are modest, and most of this seed is sold in Thailand.

Hybrids — Of all the hybrid seed sold in developing countries, only 20% is classified as proprietary;[9] the rest was developed by public sector organizations (Table 9). The global figures are dominated by China, which is among the largest hybrid maize seed producers in the world and where all seed is of public origin. When China is excluded, 60% of all hybrid seed sold in developing countries is proprietary and 40% of public origin. Thus the public sector still plays a significant role in hybrid maize breeding in the developing world. Hybrid seed developed by public breeding systems is especially important in

[9] The pedigrees of proprietary hybrids, which are developed by private seed companies, are generally not disclosed. Proprietary hybrids may or may not contain germplasm developed by the public sector.

Table 7. Maize seed sales by type of seed, 1992

Region	Commercial seed sales: Open pollinated varieties (%)	Commercial seed sales: Hybrids (%)	Total seed sales (000 t)
Sub-Saharan Africa	27	73	88
West Asia and North Africa	13	87	15
Asia, less China	47	53	80
China	3	97	688
Latin America	11	89	237
All developing countries	10	90	1,109
All developing countries, less China	21	79	421
Industrialized countries	0	100	776
World[a]	**6**	**94**	**1,885**

Source: CIMMYT 1993 Maize Seed Industry Survey.
[a] Includes 51 developing and 11 industrialized countries.

Table 8. Sales of commercial maize seed of open pollinated varieties in developing countries by type of company, 1992

Region	Share of commercial OPV sales by company type: Multi-national (%)	Private national (%)	Other non-public[a] (%)	Public (%)	Total commercial OPV seed sales (000 t)
Sub-Saharan Africa	0	18	17	65	24
West Asia and North Africa	0	0	0	100	2
Asia, less China	33	25	24	18	38
China	0	0	0	100	24
Latin America	0	53	26	21	25
All developing countries	11	24	17	48	113
Developing countries, less China	14	30	22	34	89

Source: CIMMYT 1993 Maize Seed Industry Survey.
[a] Includes NGOs, producers' cooperatives, and individual seed producers.

Table 9. Sales of hybrid maize seed in developing countries by origin of hybrid, 1992

Region	All hybrid seed sales (000 t)	Percent public origin[a]	Percent proprietary origin[a]
Sub-Saharan Africa	64	76	24
West Asia and North Africa	13	49	51
Asia, less China	42	30	70
China	664	100	0
Latin America	212	30	70
All developing countries	995	80	20
All developing countries, less China	332	40	60
Industrialized countries	774	5	95
World[b]	**1,769**	**47**	**53**
World, less China	**1,105**	**15**	**85**

Source: CIMMYT 1993 Maize Seed Industry Survey.
[a] See text for definition of public and proprietary hybrids.
[b] Includes 51 developing and 11 industrialized countries.

sub-Saharan Africa, whereas proprietary hybrids are more important in Latin America and Asia (except China). Sales of publicly developed maize hybrids are high in Brazil, Zimbabwe, and Kenya. In contrast with developing countries, in industrialized countries 95% of all the seed sold is proprietary.

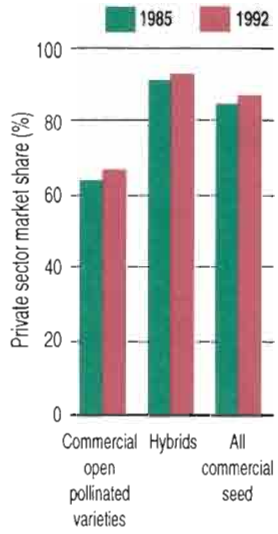


Figure 2. Private sector share of the maize seed market in developing countries (excluding China), 1985 and 1992.
Source: CIMMYT (1987) and CIMMYT 1993 Maize Seed Industry Survey.

Most hybrids developed by public sector breeding programs are produced and sold by private national seed companies (61%), followed by public sector seed companies (16%) and seed cooperatives, NGOs, and individual producers (12%) (Table 10). Multinational companies sell only 11% of all public hybrid seed sold in these countries, and the percentage drops to 2% when China is included. Hence the public maize breeding system mostly supports national seed enterprises. Proprietary hybrids are produced and sold mainly by private national and multinational companies in developing and industrialized countries. In 1992, 92% of the hybrid seed sold in developing countries was sold by non-public companies, compared to 97% in industrialized countries.

Information is not available on the shares of publicly developed and proprietary hybrid seed sold by different types of companies in previous years, but data from the previous report can be used to compare seed market shares of public and private organizations. Since the mid-1980s (and probably somewhat earlier), the private sector has dominated the commercial seed market in developing countries (Figure 2). Collaboration between public breeding organizations and private seed producers and distributors, especially national private seed companies and small-scale national seed producers, has become stronger.

Table 10. Hybrid seed market in developing countries, by origin of seed and type of company, 1992

Region	Share of hybrid seed sales by company type			
	Multi-national (%)	Private national (%)	Other non-public[a] (%)	Public (%)
Developing countries, less China				
Hybrids developed by the public sector	11	61	12	16
Proprietary hybrids	63	32	4	1
All hybrid seed	42	43	7	7
Industrialized countries				
Hybrids developed by the public sector	43	32	9	16
Proprietary hybrids	57	39	2	3
All hybrid seed	56	39	2	3

Source: CIMMYT 1993 Maize Seed Industry Survey.
[a] Includes NGOs, producers' cooperatives, and individual seed producers.

The Economics of Commercial Maize Seed Supply

As discussed earlier, producing and distributing commercial maize seed is the last stage in a lengthy process. Each step in the process, from the time research begins until seed is sold, requires substantial investment in human and capital resources.

Research and Development

Research and development (R&D) is a costly and time-consuming phase of seed development and production. Years of painstaking work are required to develop an improved variety or hybrid. The research time involved varies considerably, depending on how much and what kind of basic germplasm is available and on the degree to which it has already been improved and adapted, especially if the germplasm has been developed through a selfing program[10] (Table 11).

Starting an R&D program requires a certain minimum human and capital investment. However, expanding the breeding operation beyond this minimum level is less expensive and can make the breeding program more efficient. Breeding is thus an activity in which "economies of scale" prevail: as the scale of the operation increases, the unit costs of producing improved OPVs and/or hybrids decreases to a certain level. This is the main reason why R&D in maize seed industries often is dominated by a few enterprises with large-scale breeding programs. For example, in the US and Canada eight seed companies control more than 60% of the maize seed market (a single US company controls

[10] A plant that has been "selfed" has undergone self-pollination.

about 45%). The situation is similar in developing countries with large seed industries (López-Pereira and García 1994).

The actual R&D costs incurred in developing a given variety, inbred line, or hybrid are difficult to estimate. Breeding is a continuing activity in which many materials are crossed and tested, and only a few become commercial products. However, the level of investment in R&D can be measured as a percentage of total seed sales. Total maize R&D expenditures in the US amounted to about US$ 110 million in 1990, about 8% of the value of seed sales that year (Byerlee and López-Pereira 1994). In 1992 total R&D expenditures were 12% of the value of seed sales in Brazil and 9% in Mexico (López-Pereira and García 1994); in Zimbabwe R&D costs are about 12% of the value of seed sales.

Production/Conditioning and Marketing/Distribution

The seed production and marketing phase is very different from the R&D phase of the seed industry, especially with regard to the time and skill involved. Three distinct sets of activities are carried out, each with its associated costs. The first is producing the seed crop up to harvest; the second is harvesting and conditioning the seed, which includes packaging it for sale to farmers; and the third is marketing and distributing the seed.

Seed production costs — Several factors affect the total cost of producing commercial maize seed, particularly the maize grain price, the seed type, and the seed yield.

Maize grain price. The seed crop is often produced under contract with maize farmers ("contract growers"), especially in the case of large seed enterprises. Growers are paid a predetermined price for the seed crop which is based on the price of commercial maize grain. A company will offer a premium over the price of commercial grain as well as a guarantee to pay for a minimum seed yield, in order to attract the best and most reliable contract growers, especially those located close to the company's seed conditioning plants. Hence in countries where maize grain prices are very high (e.g., Mexico), seed production costs are high relative to countries where maize grain prices are lower. Many medium- and small-scale seed organizations in developing countries produce their own maize seed, thereby avoiding the premium paid to contract growers and reducing production costs.

Types of seed and seed yield. Seed production costs vary greatly with the kind of seed being produced (see the box, "The Continuum of Maize Seed Types and Seed Production Costs," next page). Seed of improved OPVs is the least costly to produce, mainly because seed yields are high and detasseling is not necessary. The lower cost of producing OPVs

Table 11. Time required to develop open pollinated varieties and different types of hybrids, with and without public germplasm available

Availability of germplasm and stage of breeding	Years required to develop: Open pollinated varieties	Inbred lines for:[a] Single-cross hybrids	Three-way hybrids	Double-cross hybrids
A. Public collections not available[b]				
Collection/classification	1	1	1	1
Improvement/adaptation	2	3	3	3
Selfing		2	3	4
Testing	2	5	5	5
Total	**5**	**11**	**12**	**13**
B. Public collections available[c]				
Obtain public material/classify	1	1	1	1
Improvement/adaptation	1	1	1	1
Selfing		1	2	3
Testing	2	4	4	4
Total	**4**	**7**	**8**	**9**
C. Highly homozygous public inbred lines and information on their GCA[d] and SCA[d] available	na	3	3	3

Source: Interviews with breeders from CIMMYT and private companies in Brazil and Mexico.

Note: Assumes that materials used to start the breeding program are adaptable to the region for which OPVs and hybrids are being developed and that two selection cycles per year are possible. This does not include highland areas, where only one cycle of selection is possible.

[a] The development of inbred lines for all types of hybrids is done simultaneously; in fact, the lines are developed without a specific objective and then the decision is made to use them in single-cross, three-way, or double-cross hybrids, depending on their characteristics.

[b] Assumes the breeding program starts with collections of land races and materials other than those available from public germplasm banks.

[c] Assumes materials from public germplasm banks are readily available and that these materials can be brought into the country easily and legally.

[d] GCA = general combining ability; SCA = specific combining ability.

na = not applicable.

The Continuum of Maize Seed Types and Seed Production Costs

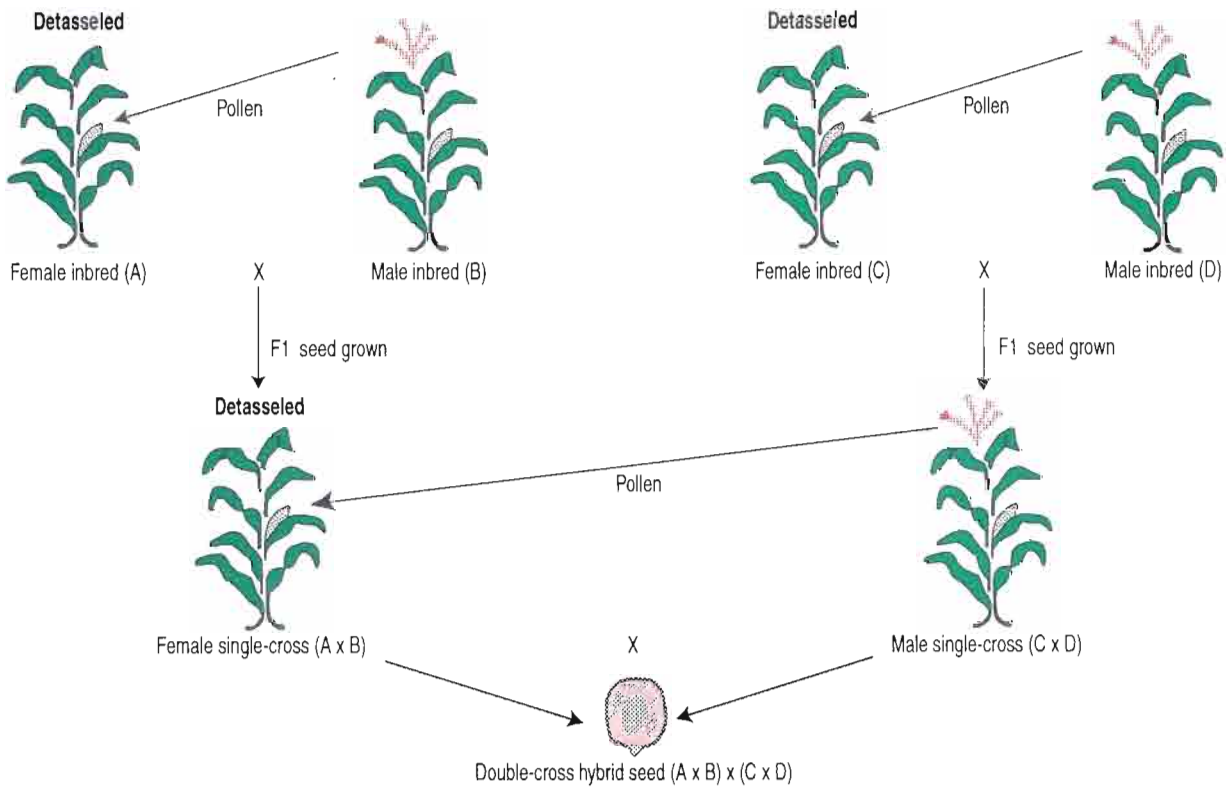
As explained in our previous report on the maize seed industry (CIMMYT 1987), the different types of maize seed available to farmers can be seen as a continuum or progression from local varieties or land races to improved OPVs, followed by non-conventional and conventional hybrids. These seed types differ from one another primarily in the technology used to produce them and in yield capability. In general, seed types having higher yield potential are the product of more complicated seed development and production technology. Production costs follow a similar continuum, increasing along with the complexity of the seed production technology.

Open pollinated local varieties or *land races* are selected and maintained by farmers, who normally select the largest and healthiest looking ears for seed after harvest (or sometimes at planting). Once the ears are selected, they are dried and saved until planting. Most farmers do not attempt to control pollination, and, if different varieties are present in an area, a large degree of intermixing (contamination) may result. Producing seed of local varieties is identical to growing a maize crop. The only additional costs — which are not generally cash costs — are related to selecting, drying, and storing the grain that will be used as seed.

When commercial seed of *improved OPVs* is produced, pollination is controlled and care is taken to prevent contamination. Precautions include growing the seed in isolation from fields sown to other maize varieties and eliminating plants that are not true to type (a practice known as *roguing*). These processes require substantial investments in labor and management and considerably increase the cost of producing commercial OPV seed relative to maize grain production. Farmers can recycle their improved OPV seed, provided pollination is regulated. If it is not, contamination may occur, and successive generations may not perform as well as the first.

Hybrids are produced by selectively crossing genetically diverse maize varieties or inbred lines. Heterosis, or hybrid vigor, results (with the proper selection of hybrid parents). The first step in the process is to secure desired traits within a variety by creating inbred lines. Lines may be inbred, through self-pollination, many times to insure that a trait becomes uniformly expressed. The result is usually a weak, short plant with low seed yields. Once lines have been sufficiently inbred, they are crossed to other inbred lines to develop experimental hybrids.

In the development of hybrids, one inbred line, cross, or variety is selected as the female parent (seed producer) and a different inbred line, cross, or variety is selected as the male parent (pollen producer). Seed of the male and female parents is planted in adjacent rows. Self-pollination of the female parent, or cross-pollination from plants other than the intended male parent, must be prevented. This is done by removing the male flowers (tassels)



Production of a double-cross hybrid.

of the female parent as soon as they appear and by isolating hybrid seed fields from other maize fields. Sometimes barrier rows of the male parent are sown on the periphery of the seed field to prevent pollination from maize varieties in other fields. Depending on the ratio of male to female rows, the area from which seed is obtained can be reduced by as much as one-third. If barrier rows are used, the seed yield per hectare is lower.

Another important aspect of hybrid seed production is timing the pollen shedding of the male with the silking of the female. Since the parents are genetically different, their flowering periods may differ. To ensure pollination, the male parent may need to be planted at a different date (usually a few days later) than the female parent. Once pollination is finished, the male rows may be harvested for grain or may be cut down. The female plants, upon maturity, are harvested for seed. This seed is the F1 (first filial generation) hybrid. Since hybrid vigor decreases with each successive generation, recycling hybrid seed is not recommended.

These special activities require more skill and raise the cost of producing hybrid seed compared to seed of improved OPVs. In developing countries, detasseling increases labor costs since it is labor intensive, although relatively low agricultural wages keep detasseling costs lower than in industrialized countries.

The number of inbred lines used in producing a particular hybrid determine what kind of hybrid it is. *Single-cross hybrids* are derived from inbred lines crossed for the first time and are the most homogeneous of the different kinds of hybrids. Crossing two single-crosses results in a *double-cross hybrid* (see the figure), one of the most popular types of hybrid seed found in developing countries. *Three-way crosses* are usually produced by selecting a single-cross hybrid as the female and a pure inbred line as the male. Due to their wider genetic inheritance, double- and three-way crosses are less homogeneous than single-cross hybrids. All of these hybrids are obtained from inbred lines and are considered "conventional" hybrids.

"Non-conventional" hybrids must have at least one parent that is a non-inbred. The other parent (or parents) may be non-inbreds or inbreds. Seed of non-conventional hybrids exhibits less hybrid vigor than seed of conventional hybrids. When one parent, usually the male, is an inbred line and the other is simply a variety, a *top-cross hybrid* is produced. When both parents are varieties and are genetically different enough to express hybrid vigor, the result is a *varietal hybrid*. Non-conventional hybrids do not show as much loss in vigor from one generation to the next as conventional hybrids.

In general, for conventional hybrids the smaller the number of inbred lines involved in the production of the hybrid and the more homogenous the lines, the lower the seed yield and the higher the cost of production. Therefore single-cross hybrids are the most costly to produce, followed by three-way crosses and double-crosses. In both OPV and hybrid seed production, net seed yields also factor into the cost of production. Broken and unacceptable seed must be discarded, as well as seed from off-type plants and diseased ears. After the seed has been sorted and cleaned, the net seed yield may be as much as 25% lower than the gross yield.

Although actual production costs for hybrids are higher than for OPVs, they only explain part of the price differential. The amount of research and development (R&D) in the production of just one hybrid is extensive. Breeders calculate that if one out of every 10,000 materials they test becomes a commercial inbred line they are doing reasonably well. It has been estimated that the R&D costs of developing a maize hybrid can be as high as US$ 1 million (Kidd and Teweles 1987).

is normally reflected in lower seed prices. Costs of producing hybrid seed are substantially higher, because extra labor is needed for detasseling and seed yields are lower. The seed yield of parent inbred lines varies depending on the type of hybrid, resulting in large differences in production costs across hybrid types. Also, producing seed of some hybrids (e.g., double-cross hybrids and three-way crosses) requires two cycles because the single-cross parents have to be produced first; other kinds of hybrid maize seed (e.g., single-crosses) require only one season.

Single-cross hybrids yield less seed than other conventional hybrids[11] because the female parent is an inbred line and usually low yielding, which makes seed of these hybrids the most expensive to produce. Seed of non-conventional (e.g., top-cross) hybrids usually incurs the lowest per-unit production costs because seed yields are high. Another reason why seed yields for all kinds of hybrids are lower than for OPVs is that plants from the male parent (which can occupy as much as one-third of the seed crop area) are not harvested for seed, which raises unit production costs.

Seed conditioning costs — The main factor affecting seed conditioning costs is the difference between the *gross* seed yield (all of the harvested seed) and *net* seed yield (the seed left after conditioning). This difference is partly related to the type of seed and its characteristics. Although much seed may be harvested, if some of it is discarded during conditioning because of defects in size, shape, or other qualities, the net seed yield will be lower and unit production costs higher. In the

[11] **For a definition of conventional and non-conventional hybrids, see the box, this page.**

development and identification of inbred lines for maize hybrids, and also for improved OPVs, good net seed yield is an important characteristic (see López-Pereira and Espinosa 1993).

Marketing and distribution costs — Marketing and distribution costs include promotion, discounts, storage, and shipment of seed to distributors. Seed companies usually assign a percentage of the total seed price for marketing and distribution costs, just as they do for R&D costs. However, marketing and distribution costs can vary substantially among companies. In general, when competition is more intense, companies have to invest more resources to emphasize their products' advantages over competitors' products — for example, by running yield trials of all the materials in the market or by holding field days. Another strategy is to provide better customer service, such as offering technical assistance and distributing free seed. Hence in highly competitive seed industries, marketing and distribution costs normally constitute a high proportion of the total price of seed, compared to industries dominated by one large enterprise. Other factors affecting marketing and distribution costs are related to the geographical distribution of the farmers served by the enterprise and the average size of their maize fields. Seed delivery costs increase if farmers are more dispersed (more outlets must be established) and if farmers require smaller quantities and thus smaller packages of seed.

Seed Prices

Along with general and administrative costs, all of the costs described above form the total production cost of commercial maize seed. A profit margin is added to this total cost to arrive at the commercial seed price. A typical breakdown of the total price of seed into cost components and gross margin is presented in Figure 3. Direct production and conditioning costs make up less than 50% of the total price of seed, and R&D costs about 10%. This breakdown may not apply to all seed industries in developing countries, but it is relevant because of the private sector's significant presence in seed industries in many countries, and it is useful for comparing the cost and pricing structure of seed companies across countries. For example, the structure of seed production costs in India, Mexico, and Brazil (Table 12) is remarkably similar, despite differences in the size and sophistication of the maize seed industry in these countries, and also resembles that presented in Figure 3.

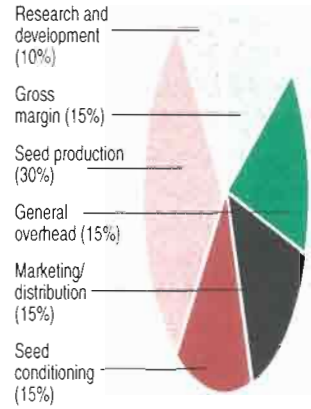


Figure 3. Typical breakdown of the price of hybrid maize seed.
Source: Pioneer (1992), Sehgal (1992).

Other factors affecting the price of seed — Factors unrelated to production costs also contribute to differences in seed prices across countries. A seed industry in which many companies participate is likely to be more efficient than an industry dominated by one or two companies. In such a competitive setting, firms will have to exploit every opportunity to reduce production costs, although marketing and distribution costs may actually increase. If commercial seed is produced from parent seed of materials developed by the public sector, and/or if public sector extension programs promote the use of improved seed, the actual costs borne by private companies are generally low, especially R&D and promotion costs. By using improved materials generated by the public sector, competitive small-scale private seed enterprises can develop, which widens competition and helps to keep seed prices low. Commodity price support policies, input price policies, and credit policies also affect the profitability of commercial maize production, as well as the cost of seed production and thus seed prices. For example, high guaranteed prices

Table 12. Production and processing costs of double-cross hybrid maize seed sold by small private companies in Brazil, Mexico, and India, 1992

	Brazil		Mexico		India	
	Cost (US$/kg)	Percent of sale price	Cost (US$/kg)	Percent of sale price	Cost (US$/kg)	Percent of sale price
Basic seed[a]	0.18	16	0.20	12	0.08	14
Seed production	0.36	33	0.63	38	0.19	32
Seed conditioning	0.08	7	0.11	7	0.08	14
Total production and processing	**0.62**	**56**	**0.94**	**57**	**0.35**	**60**
Sale price of hybrid seed	**1.10**	**100**	**1.66**	**100**	**0.58**	**100**

Sources: López-Pereira and Espinosa (1993) for Mexico, López-Pereira and García (1994) for Brazil, and CIMMYT-Indian Agricultural Research Institute survey for India.

[a] Parent seed sold by public sector organizations to private seed companies. This cost can be considered as part of the research and development cost for these companies.

for maize in Mexico in the early 1990s made maize production attractive, raising the demand for hybrid seed (see López-Pereira and García, 1994, and Part 2 of this report).

Average seed prices in developing countries— Given the many factors affecting seed production costs and prices, how do actual commercial maize seed prices vary throughout the world? Double-cross hybrids are among the most popular hybrids in most developing countries, whereas farmers in industrialized countries favor single-crosses. On average, in developing countries (excluding China) double-cross hybrids cost US$ 1.69/kg and OPVs US$ 0.61/kg; in industrialized countries single-cross hybrids cost US$ 3.81/kg (Table 13).

Table 13. Price of maize seed in developing and industrialized countries, by seed type, 1992

Seed type	Price of commercial seed (US$/kg)	
	Developing countries, less China	Industrialized countries
Improved open pollinated varieties	0.61	0.78
Non-conventional hybrids[a]	0.82	..
Double-cross hybrids	1.69	3.70
Three-way hybrids	1.27	4.23
Single-cross hybrids	2.60	3.81
Average for all hybrids	**1.68**	**3.86**

Source: CIMMYT 1993 Maize Seed Industry Survey.
[a] Top-cross hybrids, varietal hybrids, etc.

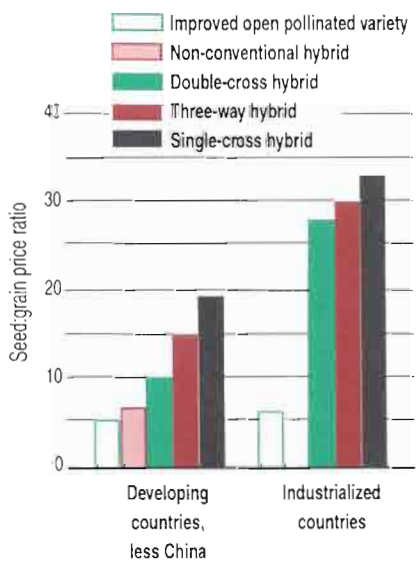


Figure 4. Maize seed prices by type of seed, 1992.

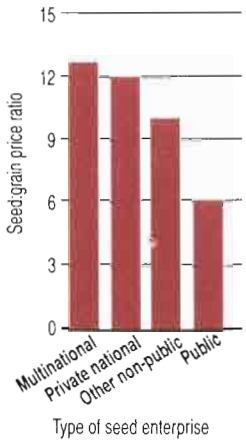


Figure 5. Double-cross maize hybrid seed:grain price ratio for different types of seed enterprises in developing countries, excluding China, 1992.

Expressing the price of seed as a ratio of the price of maize grain removes local price distortions and enables us to compare prices across locations. The seed:grain price ratio averages 5:1 for OPVs and about 10:1 for double-cross hybrids in developing countries, excluding China (Figure 4). In industrialized countries, double-cross hybrids sell at 28 times the price of grain, and single-cross hybrids at 33 times. In China the seed:grain price ratio is 1.7:1 for OPVs and 4.0:1 for single-cross hybrids. The low seed prices in China and in many other developing countries partly reflect low labor costs, low R&D costs associated with the use of public germplasm, and subsidies to some maize seed producers.

Several other trends can be discerned in seed prices by region, type of company, and seed type. Latin America has the highest seed:grain price ratios for OPVs, and public seed companies, NGOs, and cooperatives sell OPV seed for substantially less than private seed companies. Latin America also has the highest seed:grain price ratio for double-cross hybrids. Prices of many kinds of hybrid seed are lower in Africa than in other regions (Table 14).

In general, multinational seed companies sell hybrid seed at higher prices than other seed enterprises in developing countries. Private national seed companies, NGOs, and cooperatives all price double-cross hybrid seed at about the same level (Figure 5).

The increases in seed price from OPVs to non-conventional hybrids to conventional hybrids, as well as differences in seed prices across countries, can be seen in Figure 6. In many developing countries, the price of conventional hybrid seed is less than 10 times the grain price (although prices are very high in Pakistan, Thailand, and Mexico), and the price of OPVs is less than five times the grain price.

Table 14. Ratio of the price of maize seed to the price of grain in developing countries (excluding China), 1992

Region	Seed:grain price ratio				
	Open pollinated varieties	Non-conventional hybrids	Double-cross hybrids	Three-way hybrids	Single-cross hybrids
Sub-Saharan Africa	4.9	6.6	6.8	5.2	6.1
West Asia and North Africa	3.8	..	8.4	8.6	16.1
Asia, less China	5.1	4.4	6.8	10.8	24.1
Latin America	5.4	..	10.3	26.3	23.3
All developing countries, less China	**5.1**	**6.5**	**10.1**	**14.7**	**19.1**

Source: CIMMYT 1993 Maize Seed Industry Survey.

The Economics of Adopting Improved Seed

Many factors can influence a farmer's decision to purchase seed. Information on the availability and characteristics of improved seed affects a farmer's knowledge of the new seed and access to it, as well as his or her perception of the risks involved in using it. Other factors influencing the decision to purchase improved seed include the difference in cost between the improved seed and the seed currently used, the yield advantage of improved seed over the current seed, and the cost of capital needed to finance the purchase.

The Cost of Seed

Maize farmers have different seed options, each with different cost implications. If a farmer opts to use seed selected from the previous maize harvest, regardless of whether it is seed of a local variety, OPV, or hybrid, the price of seed will be similar to the price of commercial grain. This seed will normally be priced slightly higher (e.g., 20%) than commercial maize grain to account for the extra care taken by the farmer in selecting and storing it for several months.

A second option is for the farmer to use commercial seed. As we have seen, the price of commercial seed will vary depending on the type of seed, its origin, and the type of enterprise that sells it. In *those developing countries* where farmers tend to sow a larger percentage of their maize area to hybrids (Figure 7), seed prices tend to be relatively low. Low initial seed:grain price ratios (on the order of 10:1 or less) thus appear to be a necessary condition to encourage farmers to adopt hybrids when the seed industry is beginning to develop. This price-adoption relationship is not unique to developing countries. Although seed:grain price ratios for (single-cross) hybrids in the US are currently 33:1, when (double-cross) hybrids were first adopted during the 1930s and 1940s, the ratio was less than 10:1 (Byerlee and López-Pereira 1994), partly a result of the availability of publicly developed hybrids.

However, low seed prices alone may not be a sufficient condition for widespread adoption of improved seed (Figure 7). In fact, in some cases low seed prices can be undesirable if they discourage private seed sector development and R&D investment (Byerlee, Morris, and López-Pereira 1993). Setting policies for improved seed prices thus becomes a balancing act between making seed available to farmers at affordable prices and providing sufficient incentives for the private sector to invest in R&D and seed production/distribution. Because seed prices remain relatively low in many developing countries, the total cost of seed is still a small part of the total variable costs of maize production. Even when hybrid seed is used, the total seed cost usually accounts for less than 10% of all costs (Byerlee and López-Pereira 1994). However, as the seed industry matures and a continuous stream of higher quality improved OPVs and hybrids becomes available, farmers will be willing to pay higher prices for seed if it offers sufficient productivity gains to make it economically attractive.

Another element in the total cost of seed is the amount of seed planted per hectare. Seeding rates for monocropped maize average around 25 kg/ha across developing countries, but there is wide variation among regions and countries and within localized production zones. Seeding rates in certain areas of Indonesia, where farmers overplant to compensate for expected losses to insects during the seedling stage, average more than 40 kg/ha (Krisdiana et al. 1991). In the

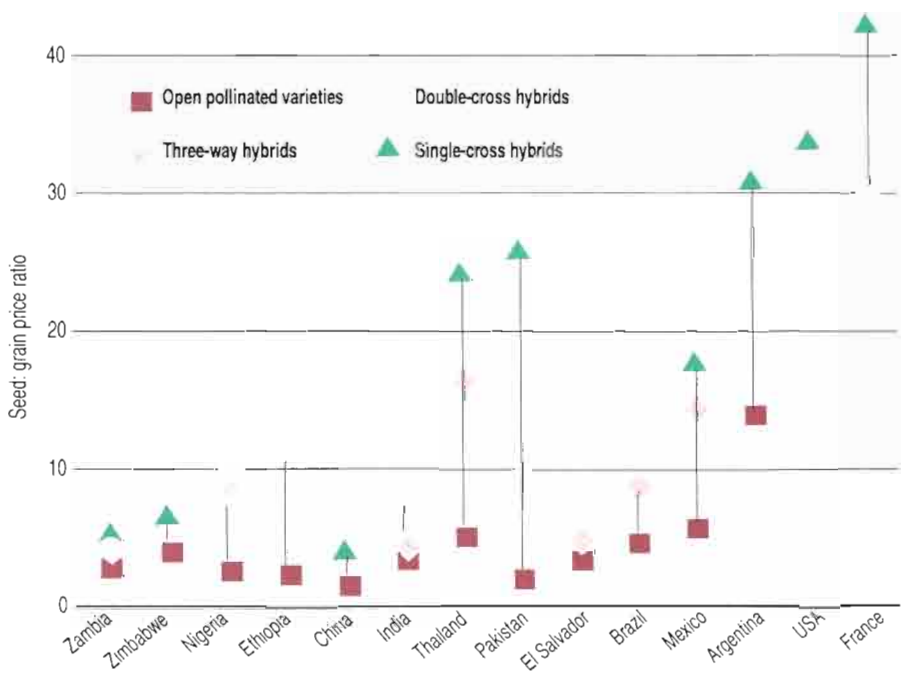


Figure 6. Maize seed:grain price ratios by seed type, selected countries, 1992.
Source: CIMMYT 1993 Maize Seed Industry Survey.

mountains of northern Pakistan, farmers frequently sow 80-100 kg/ha of seed so that they can obtain fodder from thinnings in addition to grain (Byerlee, Khan, and Saleem 1991). On the other hand, seeding rates in Central America are around 19 kg/ha. The seed size and the total weight of seed planted per hectare vary as well, depending on the type of seed used. Since commercial maize seed is sold by weight in most developing countries, this also affects total seed costs.

Seed Recycling: A Strategy for Reducing the Cost of Seed?

Sometimes maize farmers recycle seed because they lack cash or credit for purchasing seed or because commercial seed is not available on time. Farmers may also recycle seed because they believe it makes sense economically. The extent of seed recycling, the degree to which seed becomes mixed through out-crossing with other varieties, and the seed management practices of farmers who recycle seed are not well understood, as most of the evidence is anecdotal. A comprehensive study in Pakistan found that after three years of recycling, seed of improved OPVs had been contaminated by more than 50% and that plants grown from that seed had become increasingly similar to the local varieties (Longmire and Mohammed 1994). Another study in Nepal found that farmers using recycled OPV seed noticed significant changes in maize plant type (Seeley 1988). The study stressed the need for farmers to have access to new seed every year and for Nepal to develop a long-term strategy that would ensure a continuing supply of OPV seed. A study in southern Mexico found that maize fields exhibited substantial mixtures of improved OPVs and local varieties (Bellon and Brush 1993). Though they are inconclusive, these examples suggest that recycled seed can become contaminated after only a few seasons. Hybrid seed recycling, although reported less frequently than OPV recycling, does occur in some countries and under certain conditions. A recent study of the effects of using recycled OPV and hybrid seed in Mexico found that, given conditions in the study area, the best alternative over two seasons was to use commercial seed of double-cross hybrids in both seasons, and that recycling either OPVs or hybrids was uneconomical (Espinosa, López-Pereira, and Tadeo 1994).

Data from the Maize Seed Industry Survey indicate that only about 26% of the OPV seed used by farmers is commercial seed and that the remainder is recycled (Table 15). The average recycling period for OPV seed was 5.7 years. (In other words, maize farmers in developing countries purchase improved OPV seed every six years.) This average recycling period is high compared to the recommended rate of three to five years (see, for example, Longmire and Mohammed 1994). Regional recycling periods are dominated by a few countries that produce large volumes of OPV seed and also report relatively low recycling periods, such as Thailand and Brazil, but many countries actually report very long seed recycling periods. Of the 46 countries where improved OPVs are grown, 50% were found to have recycling periods surpassing five years. Only six countries reported that farmers purchased commercial OPV seed every year. Clearly, a large proportion of developing country farmers choose to recycle OPV seed, even though the savings from recycling may be more than offset by losses incurred from using lower-yielding recycled seed. It may be that farmers' decision to recycle seed is less a cost-reducing strategy than a response to an institutional environment that discourages the regular supply of commercial OPV seed.

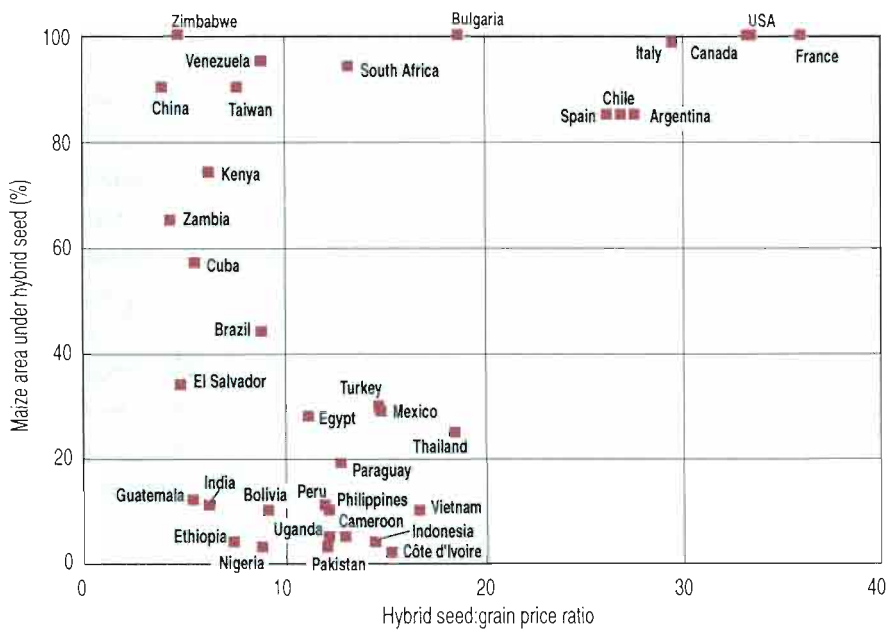


Figure 7. Ratio of seed to grain prices and adoption of hybrid maize seed in selected countries, 1992.

Yield Advantage of Improved Seed

One very important factor affecting adoption of improved maize seed is the yield advantage it offers compared to a farmer's current material. The degree of the yield advantage depends on whether one is comparing yields of a local variety and an improved OPV, two improved OPVs, an improved OPV and a hybrid, or two hybrids. The yield advantage of improved OPVs and hybrids over local varieties can vary greatly depending on growing conditions (see the box, "The Continuum of Maize Seed Types and Seed Production Costs," page 10). The yield advantage expressed by one type of maize over another under good growing conditions may diminish under harsh growing conditions. In areas where hybrids are replacing improved OPVs (e.g., Thailand, parts of India), it may be difficult to achieve yield increases of more than 20-25% over the yields currently obtained by farmers (Byerlee, Morris, and López-Pereira 1994). (See the box, "Small-Scale Farmers' Use of Hybrid Maize Seed," page 18). For example, across various sites in Mexico and Central America, a yield advantage of 10% was reported for double-cross hybrids compared to improved OPVs and a 16% advantage was found for single-cross hybrids compared to improved OPVs (Córdova 1986). The first hybrids tested in Iowa in the 1930s yielded only 10-15% more than the best improved OPVs, but their yield advantage widened during drought years (Iowa State Department of Agriculture 1935). Recent evidence has shed more light on the debate over the yield advantage of hybrids under low-input conditions and farmers' management (Chiduza et al. 1993, Byerlee et al. 1994). Although not conclusive, this evidence seems to show that, even in marginal conditions and under traditional management practices, on average hybrids may perform better than local varieties, most notably during drought years. However, more extensive testing of hybrids and improved OPVs under low-input, farmer-managed conditions is needed to elicit more definitive conclusions.

Risk and Cost of Capital of Purchasing Commercial Seed

For improved seed to be attractive to farmers, it must not only generate additional income to repay the higher cost of seed and any other costs, but it must also provide an extra return to compensate the farmer for the risk taken in using a new technology. Even though improved seed may promise higher *average* yields, yields may show *greater variability* from season to season. Increased yield variability, actual or perceived, can be seen as an important disadvantage, especially by small-scale farmers who depend on the maize crop for home consumption and place a high value on food security. A marginal return of at least 100% generally is needed to make investing in a new technology attractive to farmers (CIMMYT 1988). In other words, every additional dollar invested in new, improved seed will have to generate at least two dollars in additional revenue. Some seed companies estimate that their product has to offer a much higher marginal return, on the order of 300% or more, to be attractive to farmers (McMullen 1987, Sehgal and Rompaey 1993).

Finally, even with the assurance that average yields will be higher, other factors may affect a farmer's decision to purchase improved seed. Cash may be a constraint to farmers who would otherwise be willing to pay for improved seed. With improved seed, especially hybrids, a complete package of complementary inputs is often recommended, and farmers must gauge whether they can afford these inputs and whether they will be available when needed. For example, the area planted to hybrid maize is not expanding rapidly in the Philippines, partly because improved OPVs are replacing hybrids in some regions. The OPVs cost less and perform reasonably well even at input levels lower than those recommended for hybrids (Oliva et al. 1990, Oliva 1990). Another important factor affecting adoption, particularly where the seed industry is underdeveloped, is continued access to improved seed.

Table 15. Average recycling period for seed of improved open pollinated varieties, developing countries, 1992

Region	Improved OPV seed used (000 t)		Recycling period[a] (years)		
	Total	Commercial	Lowest	Average	Highest
Sub-Saharan Africa	44	11	1.4	5.7	12.0
West Asia and North Africa	4	2	1.0	4.2	7.1
Asia	155	39	1.1	6.4	13.4
Latin America	91	25	1.0	4.6	7.2
All developing countries	**294**	**77**	**1.0**	**5.7**	**13.4**

Source: CIMMYT 1993 Maize Seed Industry Survey.

[a] The recycling period is estimated as the ratio of total improved OPV seed to commercial OPV seed used in each country. Regional averages are weighted by total improved OPV seed used in each country. Excludes China and Mozambique.

Break-even yield curves — Break-even yield curves show the minimum yield advantage required from improved seed (relative to a given base yield) to compensate the farmer for the extra investment and the risks taken in using the seed (Figure 8). Break-even yield curves illustrate two important characteristics of the economics of adopting improved seed. First, for a given seed price level, the yield advantage required from improved seed decreases as the current yield level increases. At very high current yields, the required yield advantage is less than 20% in most cases. Second, at relatively low current yield levels, the required yield advantage of improved seed increases substantially as the price of seed increases. In the hypothetical example depicted in Figure 8, a current yield level of 2 t/ha would require a yield advantage of slightly less than 20% if the seed:grain price ratio is below 10:1. In comparison, a seed:grain price ratio of 20:1 would require a yield advantage of around 40% to make changing varieties profitable for farmers, given this low level of yields.

This analysis supports the evidence that farmers producing maize at low yield levels are more likely to adopt improved seed where seed:grain price ratios are less than 10:1. It also helps to explain how, as farmers' yields and incomes rise, smaller *relative* yield advantages are needed to make the use of improved seed attractive, even if seed prices increase. This is a major economic reason why farmers in areas where growing conditions are favorable are more likely to use improved seed and other inputs than farmers who produce maize under marginal growing conditions.

The Future World Maize Seed Industry

The structure, size, and products of the world maize seed industry will continue to be influenced by rapidly changing circumstances. Although everyone agrees that the technical, legal, and institutional issues described below are pertinent to the future of the maize seed industry, no-one is certain of how they will actually play out in individual countries. What *is* certain is that they promise to be complex and occasionally controversial, and any inquiry into the future of the maize seed industry should take them into account.

The Technological Environment: Biotechnology

It is difficult to predict when biotechnology might begin having a major impact on maize production, but the products of biotechnology are not likely to become an option for maize farmers in industrialized countries before the start of the next century and perhaps another 5-10 years later in developing countries. But no matter when they are introduced, most products and processes of biotechnology research on maize will be embodied in improved seed. The impact on maize seed industries is likely to be profound.

It is generally agreed that in the foreseeable future molecular biology techniques will not replace conventional breeding methodologies but rather will make them more efficient and less costly. Byerlee (1994) describes two specific possibilities. First, the time required to develop superior materials can be reduced by using molecular markers and improved diagnostic tools that permit more precise selection of plants carrying genes for desirable traits (or rejection of plants possessing unwanted genes). This would substantially reduce the R&D costs of producing a variety or hybrid. A second possibility is genetic transformation — the transfer of genes from unrelated species to provide traits that would not be available through conventional breeding techniques. The complexity of this process makes it likely that the first products will emphasize traits transferred through a single gene. Research on genetic

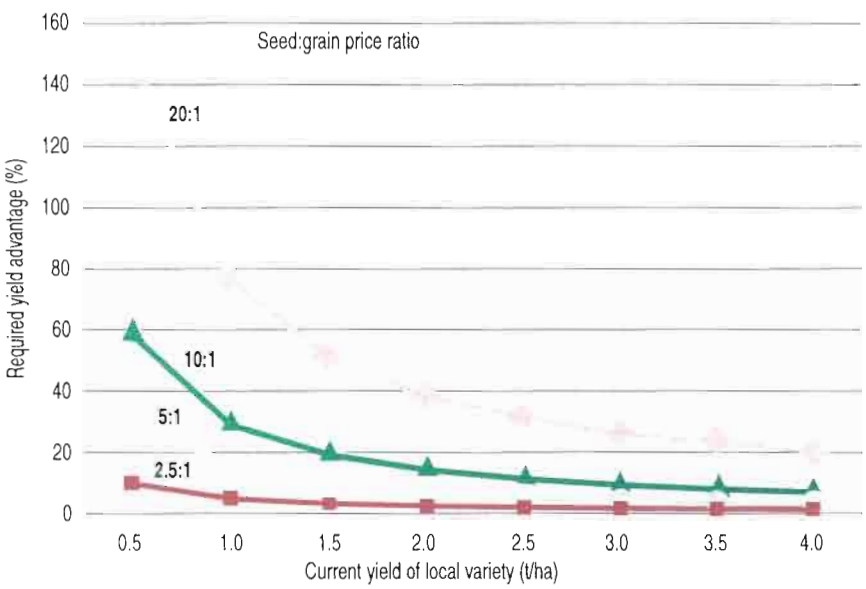


Figure 8. Required yield advantage to compensate the additional cost of improved seed, including a 100% return to investment, for different seed:grain price ratios and different current yield levels of the local variety.

Small-Scale Farmers' Use of Hybrid Maize Seed

Conventional wisdom once asserted that smallholders were not likely to adopt hybrids, because smallholders would not have the cash to purchase seed annually or the use of hybrids would not compensate them for the increased seed cost and risk. However, the conventional wisdom has since been proven wrong; hybrid maize has come to be grown by numerous small-scale farmers under a surprising range of conditions.

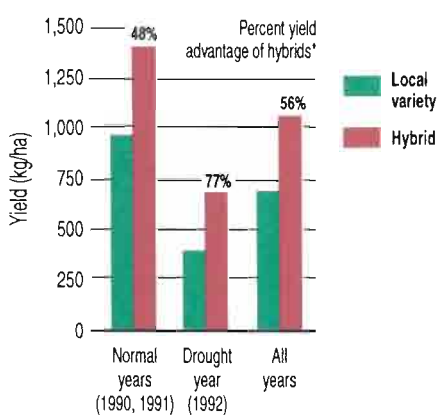
Zimbabwe is probably the best-known instance of small-scale farmers extensively adopting hybrid maize seed. When SR-52, thought to be the first commercial single-cross hybrid released anywhere in the world, was released in 1960, large-scale commercial maize farmers were the first to adopt it, but smallholders eventually followed suit. Use of hybrid maize seed in Zimbabwe rose from virtually zero in 1950 to 55% in 1975, and by 1990 nearly all of the maize produced in the country came from hybrid seed.

As maize area expands into Zimbabwe's semi-arid regions, researchers are evaluating the appropriateness of hybrids for these areas. For example, Chiduza et al. (1994) conducted on-farm experiments for two years to test yields of 10 experimental varieties and five commercial hybrids in a semi-arid region of Zimbabwe. The hybrids yielded consistently better than the OPVs, both at zero levels of fertilizer (20% yield advantage for hybrids) and at high levels (18% yield advantage for hybrids). The authors argue, however, that OPVs may be more practical for cash-constrained farmers and should be made available.

Recent data from Malawi provide the most convincing evidence to date that hybrids perform well under very low input levels and drought stress. Most of Malawi's 1.3 million hectares of maize is cultivated by very small-scale farmers. Until recently these farmers grew little improved maize. One reason for the low adoption rates was that Malawi's small-scale farmers, who produce maize primarily for home consumption, prefer flint types because of their on-farm processing and storage characteristics. In 1990, Malawi's national research system released two new hybrids (MH17 and MH18) with on-farm processing and storage characteristics similar to local flint varieties but with yields as high as dent hybrids. Even in the 1991-92 drought they performed better than the local varieties (see the figure).

Evidence from farmer surveys (Smale et al. 1993) suggests that MH17 and MH18 will be widely acceptable to small-scale farmers, and adoption is accelerating rapidly. Hybrid seed sales jumped from about 2,000 t in 1988 to about 8,000 t in 1993, enough to cover approximately 320,000 ha, or about 25% of Malawi's total maize area.

Smith (1993) has studied the feasibility of hybrid maize in the Northern Guinea Savanna of West Africa, where little improved seed has been used. While recognizing the need for further research, the author concludes that hybrids perform better than improved OPVs even at low fertilizer levels and that the yield advantage of hybrids may well be maintained at moderate fertilizer levels. However, the author estimates that a yield advantage of around 50% may be necessary to make hybrids economically attractive to farmers and observes that OPVs can play an important role in commercial and marginal maize production areas, given the underdeveloped seed systems in the region.



Yields of hybrid and local maize under low-input conditions (zero fertilizer) in on-farm demonstrations, Malawi, 1992.

Source: Smale et al. (1993).

* The hybrids used in the trials are primarily MH17 and MH18 (top-crosses). Yields are averages of 110 sites in 1990 and 1991 and 102 sites in 1992.

El Salvador's maize farmers are mostly small-scale producers who cultivate maize on steeply sloping hillsides, usually with sorghum and/or dry beans. Until recently, maize hybrids occupied about 70% of the maize area (Walker 1981, CIMMYT 1990), largely owing to successful collaboration between public and private organizations for developing and delivering improved seed (Morris, Clancy, and López-Pereira 1992). However, in the wake of logistical and organizational problems, combined with a reassessment of priorities in the research system, use of hybrid seed has fallen to below 50% of the maize area (H. Córdova, pers. comm.). This situation is expected to change, however. The research system has fully resumed its activities, including the production and supply of basic seed of the public hybrids. The use of hybrids should receive further impetus from the release of two new hybrids resistant to corn stunt disease, which yield 25-30% better than the two most popular (but susceptible) hybrids (Aguilúz et al. 1991, Córdova 1991).

The case of hybrid seed adoption in Thailand, a country where improved OPVs are used extensively, is an interesting variation on the cases presented above. After the phenomenal success of the "Suwan" OPVs (Sriwatanapongse, Jinahyon, and Vasal 1993), the seed industry developed quickly, especially private companies (including multinationals). At first the companies only produced and marketed the public varieties, but in the early 1980s they started their own breeding programs, oriented toward non-conventional hybrids. However, these hybrids showed a very small yield advantage (less than 10%) over Suwan-1, which limited their competitiveness in the Thai maize seed market, dominated by OPVs (C. de León, pers. comm.). Even in the late 1980s, a study concluded that maize hybrids yielded only about 19% more than the

OPV Suwan-1; this small yield difference, combined with substantial differences in seed prices between OPVs and hybrids, made hybrid seed only marginally more profitable than the OPV (Wattanutchariya, Kao-ian, and Vonyordpun 1987). Since then, increased competition within the private sector and the development of higher yielding hybrids may have made hybrid seed more attractive to Thai farmers. Current commercial hybrids perform better than the popular Suwan variety, both under drought stress and under normal conditions (Prasatsrisupab et al. 1990). Nevertheless, seed:grain price ratios are 6:1 for Suwan-1, 15:1 for three-way hybrids, and 23:1 for single-cross hybrids, similar to those prevailing in the mid-1980s (CIMMYT 1987), so hybrid seed remains much more expensive than OPV seed.

All of these examples run contrary to the notion that hybrids are for commercial farmers only (see Byerlee and Heisey, 1993, for a recent discussion; see also Friis-Hansen, 1989, for a strong position *against* using hybrids under low-input conditions.) The fact that hybrids perform well under *some* low-input conditions does not indicate that they are the best strategy for *all* small-scale farmers, but hybrids should be evaluated as an option. More convincing evidence is required on the advantages of hybrids over improved OPVs (as opposed to local varieties) and on the feasibility of providing hybrid seed for low-input conditions and small-scale farmers. In many of the countries mentioned above, seed of hybrids is priced very low compared to other countries, and it remains unclear whether hybrids would be economically advantageous at higher seed: grain price ratios. In setting priorities for maize breeding, especially with regard to the development of hybrids versus OPVs, research managers must consider the economics of using hybrids compared to local varieties or improved OPVs, as well as the institutional and policy environment. Other factors that should be considered are the potential for hybrid maize in the mixed cropping systems common in many regions and the rigidity of technological packages recommended to farmers, especially for hybrid seed.

transformation of cereal crops currently emphasizes pest resistance, herbicide tolerance, quality traits, and genetically induced male sterility to facilitate hybrid seed production (Byerlee 1994).

Much controversy surrounds the genetic transformation of maize for herbicide tolerance. Some argue that herbicide-tolerant materials will foster dependence on specific herbicides (for example, see Just and Hueth 1993), discourage reductions in herbicide use, especially in commercial maize production, and ultimately harm human and environmental health.[12] Others caution that herbicide-tolerant maize will favor commercial farmers over small-scale farmers (and laborers) who control weeds by hand (see, for example, Hobbelink 1991). However, in some cases herbicide-tolerant maize may benefit both small-scale farmers and the environment. For example, some small-scale farmers in parts of Mexico and Central America now use herbicides for land preparation and weed control in lieu of traditional slash and burn methods. This practice makes it possible to maintain a mulch of crop residues and weeds on the soil surface, which reduces erosion and improves moisture retention. However, these farmers typically use paraquat, a dangerously toxic herbicide. Maize varieties genetically engineered for tolerance to less toxic herbicides could encourage those farmers to use the less toxic chemicals (Byerlee 1994).

The use of agricultural chemicals could be reduced substantially by the development of materials possessing genetic tolerance to insects and other pests, mainly through the incorporation of special Bt genes and proteins.[13] This approach is emphasized by some private enterprises, national public sector organizations, and IARCs and is expected to bring substantial benefits to developing country farmers.

Another line of research, for which results remain uncertain and will be much less immediate, involves *Tripsacum*, a species related to maize. The objective of this research is to transfer a trait called "apomixis" from *Tripsacum* to maize (CIMMYT 1994). Apomictic plants reproduce asexually; nearly all seeds produce an exact clone of the mother plant. If apomictic maize products become available commercially, they have the potential to lower seed prices dramatically, because farmers will be able to recycle hybrid seed without loss of genetic purity (or, of course, yield potential). The use of biotechnology tools will be instrumental to this research.

The potential utility of these and other products and processes of biotechnology is apparent, but it does not dispel the uncertainty over how their introduction will affect seed prices. It is not yet clear whether the potential cost savings (e.g., through reduced pesticide use) or revenue increases (e.g., through higher yields) will offset possible increases in seed prices. While the relatively low seed prices in developing countries provide some scope for absorbing part of the price increase expected if this seed reaches the market, it is possible that the seed could be priced out of the reach of many

[12] Views on the potential effects of using herbicide-tolerant crops in the US can be found in Harrison, Jr. (1992), Duvick (1992), and Wyse (1992).

[13] "Bt" stands for *Bacillus thuringiensis*, a soil bacterium that produces insecticidal proteins that are active against specific insect groups. Molecular biology techniques have been used to transfer Bt genes to crop plants such as maize, resulting in transgenic plants carrying resistance to specific insect pests (e.g., Vaeck et al. 1987).

small-scale farmers in the developing world. This reinforces the importance of public sector NARSs and IARCs in underwriting the cost of R&D for maize hybrids directed at small-scale farmers.

The Legal Environment: Intellectual Property Rights

One issue debated vigorously in many national and international fora is intellectual property rights (IPRs) legislation. The debate ranges from whether such legislation is necessary at all to its implications for restricting access to certain technologies, especially biotechnology processes and products. Because it is not yet clear when, whether, or how the debate over IPRs will be resolved, the implications for public and private research organizations, national and international, and for farmers themselves remain the subject of intense speculation.

Maize hybrids (although, obviously, not OPVs) generally have been protected by keeping the identity of the parent lines secret, which has been sufficient to stimulate private sector investment in maize breeding in many countries, even in developing countries without legal forms of protection (see, for example, Byerlee and López-Pereira 1994; López-Pereira and García 1994). Thus one of the questions generated by the debate over IPRs is to what extent intellectual property legislation will foster the development of a maize seed industry beyond what would have been the case without IPRs. It is likely that the effectiveness of IPRs as a mechanism for encouraging private sector R&D and the development of maize seed industries in developing countries will vary with the sophistication of the industry. An emerging private sector benefits from the free availability of public germplasm from the NARSs and IARCs,[14] so initially local private firms do not demand IPRs. As private sector investment in R&D grows, proprietary materials begin appearing in the market.

In countries where small-scale farming predominates, IPRs may actually be ineffective for protecting maize materials because of the high costs of enforcement and low potential for revenues from royalties (Byerlee 1994). However, it could be argued that IPRs would increase private R&D in maize, since R&D is likely to be at less than optimal levels in the absence of such protection.

A related and more disturbing question is whether IPRs are needed for developing countries to gain access to the products of biotechnology research. Of course, a patent on a variety or gene in industrialized countries does not deny access by small-scale farmers in developing countries to that variety or gene, even in the absence of IPRs in developing countries. Once a variety is released in any country, it is only a matter of time until it is available to breeders in other countries who can transfer useful genes through conventional breeding.

Does this imply that developing countries can ignore the current pressure to implement IPRs for plants and biological processes? There are at least three reasons why this may not be the best strategy (Platais and Collinson 1992). First, there will be a delay of several years in obtaining and adapting useful germplasm to local needs. With IPRs, it is possible that an agreement could be negotiated, and suitable varieties made available to farmers, at a much earlier stage. Second, access to biotechnological processes, useful for creating new varieties more efficiently, may be more important than access to germplasm. These processes will have to be purchased under some licensing or royalty system. Without access to these processes, a country might limit its potential to develop and export its own biotechnological innovations (Byerlee 1994). Third, IPRs for biological processes and products are now an integral part of international agreements such as the GATT. If a country, as part of its overall economic policy, wishes to benefit from these agreements, IPRs may be needed.

Another issue under debate is which form of IPRs to adopt. The two basic forms under review are plant variety protection (or plant breeders' rights) and the patenting of genes, biological processes, and varieties (known as "utility patents" in the US). The US is one of the few countries where plant varieties can be patented, and patents have been used to protect maize inbreds. Most developing countries considering intellectual property rights legislation tend to prefer plant breeders' rights over patents. While recognizing that plant breeders' rights are not perfect, advocates of this form of IPRs argue that it adequately guarantees that the owner can exploit any protected material and, at the same time, allows protected materials to be used widely for research. Also, recent advances in gene mapping techniques promise to simplify the application and enforcement of plant breeders' rights. Utility patents are more controversial; they are expensive to obtain, they have not been widely tested in the courts, and patents on living organisms are opposed by many

[14] See Barton and Siebeck (1994) for an analysis of the possible effects of the use of intellectual property protection on materials developed by seed organizations with source germplasm originating in the IARCs and a discussion of alternatives that the IARCs are considering to achieve unrestricted access to the genetic resources in their safekeeping.

persons. Utility patents have not been used to protect maize hybrids in developing countries, and in some countries maize hybrids are specifically excluded from patent protection under standard industrial patent laws (Evenson 1991).

The Institutional Environment: Issues for the Future

Public sector restructuring and agricultural policy changes have provided greater opportunities for the private seed sector in developing countries, but they have also raised three issues that are important to the development of seed industries.

Efficiency versus equity — The need to balance equity and efficiency when setting objectives in maize breeding and seed production and delivery is important in developing countries. Even where the private seed sector is strong, public intervention may still be needed to reduce biases in the kinds of farmers and regions served by the seed industry. The private seed sector concentrates its efforts where profit opportunities are greatest, usually seeking to reach large-scale, commercial farmers who normally grow hybrids rather than improved OPVs. Thus public sector organizations can have an important role in generating improved maize germplasm for small-scale farmers in marginal areas, especially materials adapted to local growing conditions.[15] Public research systems can also help foster the development of small-scale seed producers, which are often the main source of improved seed for poor farmers. Alternatively, public support to private sector varietal development and seed production targeted at small-scale farmers at times may be the most effective way to ensure that these farmers have access to suitable maize hybrids and improved OPVs. However, given the recent sharp reductions in support for public NARSs in many developing countries, as well as for IARCs, it is not clear how the public research system will accomplish this research agenda.

Two potentially controversial activities that the public sector is experimenting with in some countries are selling public inbred lines at close to the full price (including the recovery of R&D costs) and receiving royalties on sales of seed of public hybrids (see the box, "Brazil's Innovative Approach to Public-Private Sector Alliances in the Seed Industry," page 22). One drawback of such arrangements is their potential for biasing the research objectives of public institutes towards the development of materials for high-potential regions and away from the needs of small-scale farmers. However, public sector research oriented to small-scale farmers has in some cases been supported through sales of public improved germplasm (in Brazil, for example). In addition, there is evidence that these initiatives help increase competition in the private sector, which results in lower maize seed prices to farmers (López-Pereira and García 1994). Nevertheless, the potential for controversy exists, and it will be interesting to see the outcome of these initiatives.

Future roles of the public and private seed sectors — Maize seed industries clearly have evolved in a direction that places more responsibility in the hands of the private sector, especially in seed production and marketing. As observed earlier, public organizations were central to the development of seed industries in industrialized countries because they assumed a substantial portion of the initial R&D investment, which produced the breeding methodologies and improved germplasm used by the private seed sector (Huffman and Evenson 1993; see the box, "The US Maize Seed Industry, Past and Present," page 24). However, the great diversity of growing environments, maize farmers, and maize farming systems in many developing countries make it less likely that private companies will be able to serve the needs of all farmers and still be profitable. This implies that there is still a need for active public sector participation in maize R&D to complement private sector R&D and seed production and distribution. Specifically, the public sector can:

- Develop improved basic germplasm, inbred lines, or OPVs, thereby enhancing the competitiveness of private national seed companies and small non-public organizations that produce and sell maize seed, and, at the same time, making it more profitable for private companies to produce seed for small-scale farmers in marginal environments.

- Provide technical assistance and other support to small-scale seed producers to strengthen their ability to meet the needs of resource-poor farmers, or, alternatively, directly subsidize private seed producers' efforts to develop and distribute maize OPVs or hybrids tailored to the needs of small-scale farmers.

The strong public support for seed industries in industrialized countries during their early stages of development suggests that an integrated public-private seed sector is a good means of fostering the development of an efficient seed industry. In addition, there is evidence that collaboration between the public and private seed sectors has a substantial positive effect on maize productivity (Echeverría 1991).

[15] That is, after a careful analysis of alternative uses of marginal lands, including the potential of other crops, so that public funds are invested in activities with the greatest potential for social benefits.

Brazil's Innovative Approach to Public-Private Sector Alliances in the Seed Industry

In 1987 Brazil released the first of a series of outstanding double-cross hybrids, noted for their tolerance to acid soils, their wide adaptation, and superior yields. The first of those hybrids, BR-201, was developed by the National Maize and Sorghum Research Center (CNPMS), part of the Brazilian Agricultural Research Enterprise (EMBRAPA).

At that time, the main force behind increased maize production was the expanding maize area in the Cerrados region of central Brazil. Although the private sector was not very active in seed production in the Cerrados, EMBRAPA proposed that private companies begin distributing commercial seed of its maize hybrids, starting with BR-201, and helped form a committee to select the companies that would participate in the program. These companies would purchase basic seed (the single-crosses) for producing commercial seed of BR-201 under the technical supervision of EMBRAPA researchers. The committee was initially composed of officials from the CNPMS and the Basic Seed Production Service (SPSB), also part of EMBRAPA. Seventeen small seed companies were selected for the program, and the first commercial seed of BR-201 was produced in 1987 for sale in 1988. A modest 900 t of seed was sold that year, which represented less than 1% of the total maize seed market.

Problems with quality control led EMBRAPA researchers and the companies themselves to implement strict seed production standards. Companies that produced inferior seed were expelled from the group, and other companies were added. In 1990, the companies in the program organized themselves into an association called UNIMILHO to maintain high standards, coordinate basic seed purchases from EMBRAPA, and promote BR-201. These organizational changes turned the program around. In 1993, sales of BR-201 reached 18,000 t, representing 17% of the hybrid seed market. The UNIMILHO group (by 1993, 27 companies were members) is the third largest maize seed producer in Brazil, and BR-201 is the single most widely used hybrid.

Competition in the private seed sector has become more intense as the UNIMILHO group has become more important, resulting in more options for maize farmers and lower prices for hybrid seed (López-Pereira and García 1994). EMBRAPA has also benefited from the arrangement. Contracts with the UNIMILHO group have raised revenues from the sale of parent seed and royalties collected on gross seed sales. However, some of the large seed companies are not pleased with this situation, objecting that the inbred lines were developed using public research funds and should be freely available to everyone. (EMBRAPA does not reveal which inbred lines constitute BR-201, nor does it make them publicly available.) EMBRAPA and UNIMILHO respond that these companies are welcome to join the system, as long as they purchase basic seed from EMBRAPA and pay royalties on seed sales, something that the large companies, with strong breeding programs, are not interested in doing. They are interested in obtaining the inbred lines to develop their own proprietary materials.

Amid this controversy, EMBRAPA and UNIMILHO have developed a special breeding project within the CNPMS to develop hybrids to replace BR-201. Two are already on the market (small amounts were sold in 1993), and two others (single-crosses) should be released within the next three years.

To capitalize on the success with seed of BR-201, EMBRAPA is establishing a franchise system to produce and market seed of outstanding improved OPVs from CNPMS. Seed of the most widely used improved OPV in Brazil, BR-106, is already sold through a system similar to the UNIMILHO scheme. Under the franchise system, cooperatives produce and distribute commercial seed of BR-106 and EMBRAPA-SPSB supplies the parent seed. EMBRAPA-CNPMS will continue the improvement of BR-106, and each year a new breeding cycle will be available as basic seed. In 1993, BR-106 Cycle-9 was available; EMBRAPA claims that 25 franchisees are producing about 10,000 t of commercial seed of BR-106 for the 1994-95 crop year. (Some franchisees are members of UNIMILHO and thus also sell seed of BR-201.) In this way, EMBRAPA hopes to enable small-scale farmers who use local maize seed, recycled OPVs, and even recycled hybrid seed to obtain high quality certified OPV seed every season at low prices.

The considerable private sector investment in most commercial maize regions of the developing world, especially in Latin America, offers the public sector an opportunity to focus on basic and strategic research and on production areas bypassed by the private sector, especially marginal maize production regions. However, the trend towards generating revenues from royalties on the use of public varieties and hybrids may complicate matters. If a profit-oriented public sector becomes a competitor to the private sector in commercial areas, millions of small-scale farmers are likely to be excluded from the process of technological change (Byerlee 1994, Byerlee and López-Pereira 1994).

The need for a strategy for sustained OPV seed production and distribution — In some areas of the developing world where adoption of improved maize seed remains low (particularly marginal areas characterized by small-scale subsistence farming systems and poor access to markets), maize farmers may benefit more from the introduction of improved OPVs than hybrids. Several characteristics make OPVs more suitable for these conditions:

- Maintaining improved OPV seed is relatively simple.
- New and better varieties extracted from a population improvement program (or improved versions of existing varieties) can replace old varieties when desired.
- Costs of producing improved OPV seed are relatively low.
- To some extent, seed of improved OPVs can be transferred from farmer to farmer and can be saved by farmers for several years, thereby increasing the area sown to improved OPV seed.
- National programs can exchange germplasm of OPVs more easily than closed-pedigree materials that may involve proprietary rights.

These advantages led many breeding programs in developing countries to emphasize the development of OPVs almost exclusively from the early 1970s through the late 1980s. However, only a few successful programs were established for producing and distributing seed of improved OPVs on a sustained basis (for example, in Thailand and Guatemala). By and large, public sector programs for producing and marketing OPVs have been short-lived and fairly *ad hoc* (Smith et al. 1994, GGDP 1991, and CIMMYT 1987). Public seed companies often do not sell the newest varieties developed by breeding programs, so farmers find it difficult to replace their cultivars with more recently released materials. In addition, seed supplies may be too limited for farmers to purchase OPV seed annually. And although private sector initiative has stimulated the diffusion of hybrid seed, the private sector has shown little interest in producing and distributing seed of improved OPVs, since they do not represent a reliable (and profitable) annual market. Therefore the main impediment to diffusing improved OPVs appears to be the lack of suitable mechanisms for producing and marketing seed on a continuing basis (Byerlee and López-Pereira 1994).

One means of establishing a program to produce and distribute improved OPV seed on a continuing basis may be to strengthen local seed organizations, which often focus on producing and/or distributing seed of improved OPVs, as well as on regions and farmers that may benefit most from improved OPVs. As discussed above, public research organizations could support these seed producers as a way of achieving their own goal of reaching small-scale farmers.[16] Support may take many forms, including the continuous supply of improved germplasm adapted to local conditions; technical assistance with seed production and conditioning; the provision of credit for seed production; and the promotion of improved OPVs and hybrids to encourage adoption.

[16] See, for example, CIMMYT (1984) and Córdova, Quemé, and Rosado (1992) on the technical aspects of, and programs for, small-scale production and distribution of seed of improved OPVs and hybrids.

Conclusion

Several conclusions may be drawn from this review of the global maize seed industry. It is clear that the structure of maize seed industries has continued to change over the last 10 years, especially the interaction between the public and private seed sectors. Changes in seed laws and regulations in many countries have encouraged the increased participation of private seed organizations in producing and distributing seed. The fact that most of the materials produced and distributed by these organizations in the developing world emanate from the public sector indicates how important public breeding organizations are to the development of private seed producers.

The growing use of hybrid maize in many developing countries suggests that the private sector will further strengthen its participation in the industry, not only in seed production and distribution but in R&D. Public breeding programs are likely to continue playing an important role in stimulating the development of national private seed sectors. A system of public sector R&D, combined with private

The US Maize Seed Industry, Past and Present

The maize hybridization techniques developed in the US in the early years of this century revolutionized maize production and the seed industry. Although the private sector dominates both R&D and seed production and marketing in the US, in the early stages of development the seed industry depended heavily on public sector research, mainly by state agricultural research stations. Many of the first commercially produced materials were developed by the public sector.

The US maize seed industry, now the most sophisticated in the world, produced more than 550,000 t of seed valued at more than US$ 2 billion in 1992. Commercial seed is produced and marketed exclusively by private organizations. Seven large companies hold about a 68% share of the maize seed market, and the rest of the market is divided among numerous medium- and small-scale seed enterprises (estimated at over 300). In many cases these small enterprises are family businesses, selling no more than a few hundred tons of seed. Over the last two years, the main participants in the US maize seed market — especially the largest seed company — substantially expanded their market share (see the table), which has had implications for smaller seed producers. As total maize seed production and planted area have declined (from 591,000 t of hybrid seed in 1981 to 560,000 t in 1992), the gains of the two large companies have meant that smaller enterprises lost sales. Nevertheless, the US market concentration is still low compared to other countries such as Brazil and Mexico (see, for example, López-Pereira and Garcia 1994).

Investment in R&D (including biotechnology) by the private sector is substantial in the US, representing almost 10% of the total value of the seed market (see the figure). Although the ratio of the price of maize seed to the price of grain is high, the total cost of seed in the US is still a relatively small percentage of total maize production costs, making it an attractive investment for US maize farmers. Seed prices have risen not just because seed production costs have risen, but also because of substantial increases in R&D and promotion and marketing costs.

The public maize seed sector, composed of university and state and federal breeding research stations, conducts basic breeding research, develops and releases public inbred lines (freely available to all seed organizations), and trains maize breeders. Although it is not as visible as in developing countries, the public research system in the US traditionally has been and still is a key contributor to the maize seed industry. However, some universities are seeking royalties from private companies on the sale of hybrids based on inbred lines they release. This course of action, a response to the increasingly difficult financial situation of public organizations, resembles the actions of some public research systems in developing countries, taken for the same reason.

Foundation seed companies (FSCs) are a common form of private seed organization in the US, usually concentrating on R&D and releasing advanced, elite inbred lines which are sold under special agreements to other (usually medium- and small-scale) seed companies. The FSCs, functioning like breeding programs for many small and medium-sized seed companies, increase the efficiency with which any single company can develop its own materials. The seed companies thus avoid most of the investment required to maintain a breeding program and concentrate on testing advanced lines to identify and release good hybrids. The FSCs are not common in developing countries, partly because of the small size of the maize seed industry and the presence of public breeding organizations, which make many of their materials available to private sector enterprises. Another reason that FSCs are not common in developing countries is the lack of intellectual property rights legislation needed to enforce contracts involving the use of improved germplasm across companies.

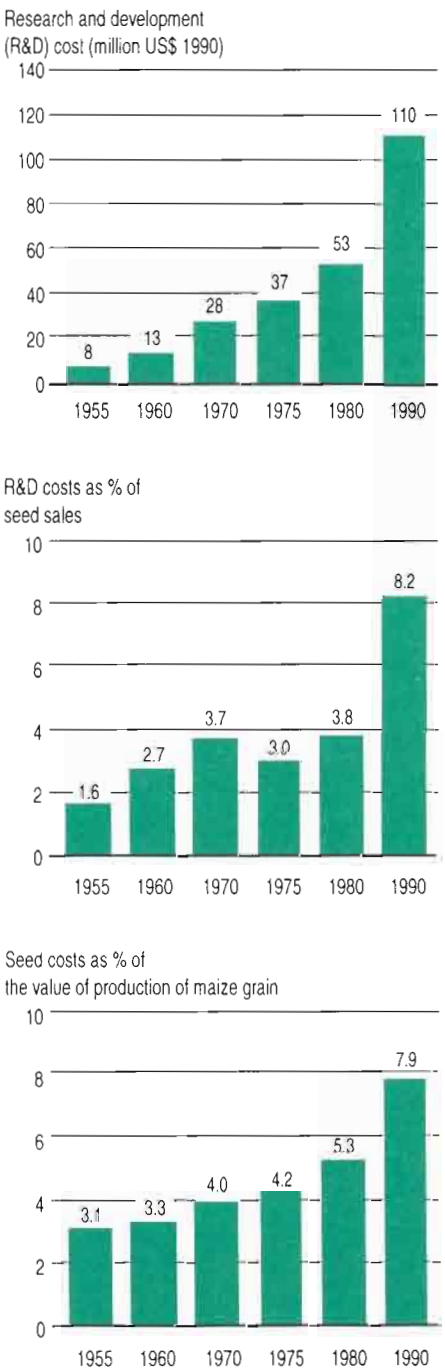
The structure of the seed industry in industrialized countries has changed dramatically in the wake of mergers and acquisitions that began in the early 1970s. Traditional seed companies were acquired by larger companies, some of which were not previously in the seed business, including chemical, pharmaceutical, food processing, and petroleum companies. As a result of these mergers and acquisitions, names such as ICI, Sandoz, Upjohn, Limagrain, and Rhône-Poulenc are common in the seed business. Whereas in 1970 virtually all the large US seed companies were independent or owned by another seed company, in the early 1990s, with a few notable exceptions, most seed companies were owned by non-seed enterprises. Of the 14 maize seed companies in the US holding at least a 1% market share in 1991, only six were dedicated exclusively to the seed business; the remainder were owned by chemical, pharmaceutical, and commodity trading companies. It is not clear whether the period of

Maize seed industry concentration in the US, 1973-93

Year	Market share of four largest seed companies (%)	Market share of eight largest seed companies (%)
1973	60	73
1978	57	69
1983	55	64
1991	51	62
1993	59	69

Source: McMullen (1987), Pioneer (1994), and authors' estimates.

acquisitions is over, but the seed industry has been characterized by a strong dynamism, and hence alliances in the business are likely to continue, especially with the increase in biotechnology products on the market in the next 10-20 years.



Trends in private sector investment in maize breeding research and cost of hybrid maize seed, USA, 1955-90.
Source: Byerlee and López-Pereira (1994).

sector R&D and seed production and marketing, is an increasingly common institutional arrangement for maize seed industries in developing countries, and it is an arrangement that is likely to increase the efficiency of public breeding research. However, no universal model fits the circumstances of each country. Each country must develop the combination of public and private institutions appropriate to its needs — its stage of development, market size, the types of farmers who grow maize, and the environments where maize is grown.

Some key issues should be addressed by public organizations as they redefine their roles in the different phases of the seed industry. An enduring issue is the need to ensure equity in setting objectives for maize breeding research and seed production and delivery. All of the evidence gathered to date suggests that the private sector will not direct its efforts in R&D specifically at developing a market for small-scale farmers; all of the seed industry success stories in small-scale agriculture described earlier present combinations of public sector breeding research and private sector seed production and marketing. It is likely that in a mature market private sector R&D will also serve the needs of small-scale maize farmers, but this has yet to occur. Public sector research is likely to remain necessary, particularly for generating improved maize germplasm for small-scale maize farmers in marginal areas, especially OPVs and hybrids adapted to local growing conditions.

As interesting as the continuing transformation of the maize seed industries may be, it should not make us lose sight of the research challenges ahead. The use of improved maize seed and crop management practices is still very low in many developing countries, mostly in tropical environments where breeding challenges are more difficult. As we have suggested, public and private sector initiative, collaboration, and ingenuity will be required to increase the productivity of maize farming in these areas, especially research by the public sector on improved materials with resistance/tolerance to biotic and abiotic stresses affecting these environments. Regional alliances of public breeding programs in countries that share similar production environments should be considered as a means of addressing these difficult challenges and making the most of scarce public research resources.

Over the next 10 to 20 years, the global maize seed industry will continue restructuring. To varying degrees, depending on individual circumstances, the public and private sectors will interact even more closely. Alliances and complementarity between the public and private sectors, both nationally and internationally, are likely to be essential for increasing efficiency, reaching large numbers of farmers, and ensuring the greatest possible attention to the needs of the poorest of these farmers. It is hoped that the final result of this sometimes difficult, often unpredictable process will be a more competitive seed industry that widens the options for maize farmers in developing countries to obtain improved seed at lower prices.

Part 2

The World Maize Economy: Current Issues

Miguel A. López-Pereira, Michael P. Filippello, and Laura Saad

Production

World maize production has continued to rise, topping the 500 million metric ton mark for the first time ever in 1992. Industrialized countries rebounded from the erratic production levels of the 1980s to reach record levels in the early 1990s (Figure 9). Developing countries have passed the 200 million ton level and produce over 40% of the world's maize.

Production increases among industrialized countries accrued mainly from yield gains, occasionally offset by reductions in maize area (Figure 10). Growth in the developing countries also resulted primarily from yield increases, accompanied by a moderate expansion in area. Developing countries, especially in sub-Saharan Africa, have experienced a slow general decline in growth in output since the 1970s. As population pressure forces farmers to occupy less productive land, average yields drop. In addition, these marginal increases in output are divided among more people, diluting their impact. Thus the positive effects of productivity growth, both in absolute and per capita terms, are lessened.

Trade

After an almost 15% drop in volume between 1989 and 1991, the maize grain market bounced back slightly in 1992 to 72 million tons, an above–average trading level for the period (Figure 11). Recent changes in the trading positions of several countries will substantially affect market volume in the near future. China recently joined the group of leading maize exporters. The European Union (EU), now largely self-sufficient in maize, imports less. The demand for imports dropped in the former Soviet Union (FSU), which faces a foreign currency shortage. Mexico, on the other hand, is expected to increase its maize imports following implementation of the North American Free Trade Agreement (NAFTA). The causes and implications of some of these shifts are discussed below.

Exporters. In 1992 the US captured only 60% of the global maize market, a relative low. Increased competition from other major exporters may partly explain this phenomenon. China is now the world's second largest maize exporter; its market share rose rapidly from around 5% in 1990 to almost 15% in 1992, most likely because of strong export promotion policies. The other major exporters were Argentina, France, and South Africa (South Africa has recovered from the 1992 drought). Competition among these top five exporters has intensified, and they increasingly rely on export promotions and subsidies to expand, or in some cases simply maintain, their market shares.

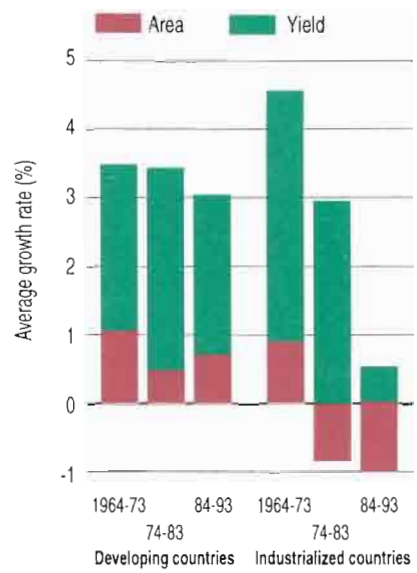


Figure 10. Sources of growth in world maize production in developing and industrialized countries, 1964-93.

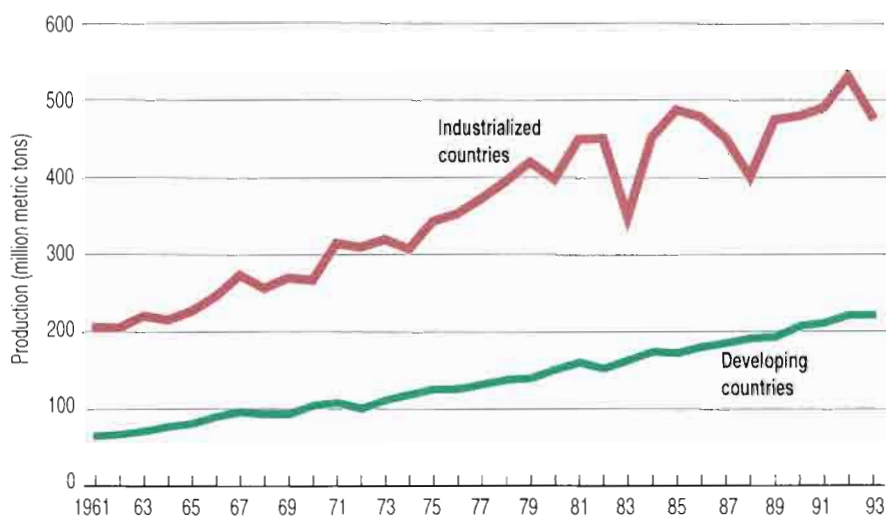


Figure 9. World maize production, 1961-93.

Importers. Industrialized countries, which import maize for livestock feed, account for a large portion of maize imports. Leading the group of major maize importers is Japan, which consistently imports 20-25% of world volume. The FSU used to rank second to Japan, but stringent import reductions have made it the fourth largest importer. South Korea has replaced the FSU as the second largest importer, followed by Taiwan; they respectively account for about 10% and 9% of world maize imports. The purchasing levels of these Asian markets may help explain China's ascendancy as a maize exporter. The implementation of NAFTA in Mexico, the fifth largest maize importer, is expected to further increase maize imports (see below).

Prices

Large fluctuations in trade volume since 1988 and significant changes in production levels seem to have had little effect on the international maize price, which has maintained a stable and slow decline since the mid-1970s (Figure 12). This is explained partly by the increasing amount of competition in the world grain market and by increased capital and information mobility.

Outlook

Demand for maize as food and feed is expected to increase with rising incomes in some developing countries and with continued population growth throughout the world. Most of this expansion in demand will take place in the developing countries, where demand is projected to grow at 4.1% annually (Byerlee and Saad 1993). Production shortfalls are possible, since production growth rates for maize in developing countries over the past decade were around 3%. In certain regions, the discrepancy between production and demand is projected to be greater. Whereas the demand for maize is predicted to grow by 3.2%/yr in sub-Saharan Africa, growth in yields over the last two decades was close to zero (Figure 13). Most production increases in the developing world will have to come from yield increases, since little additional land can be brought under cultivation. In contrast, industrialized countries have taken much land out of maize production over the past two decades. In the face of rising demand and prices, this land could always be brought back into production. Without further productivity increases, the next decade will most likely be marked by higher volumes of trade, particularly between industrialized and developing countries, and slightly higher maize prices.

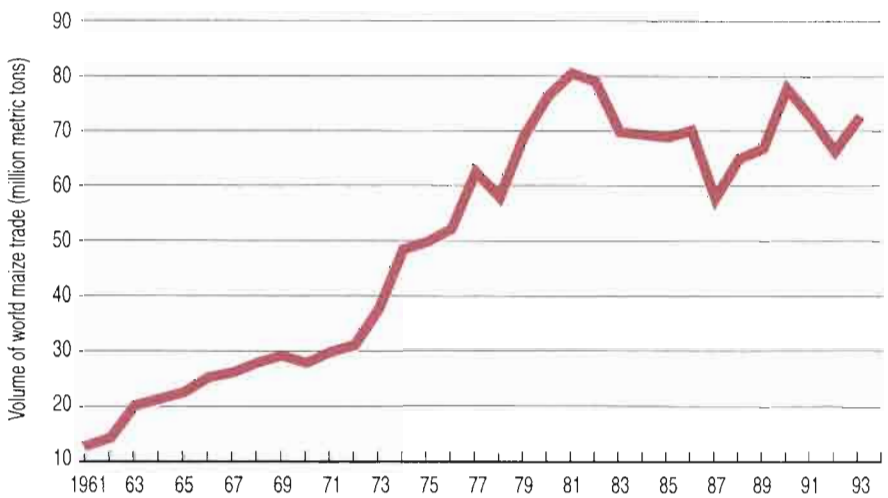


Figure 11. Volume of world maize trade, 1960-92.

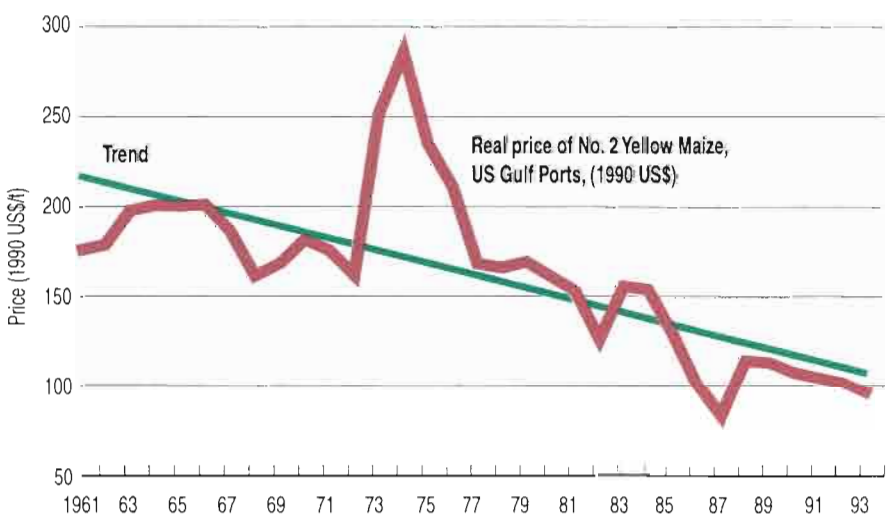


Figure 12. Evolution of the real price of maize in international markets, 1961-93.

Maize as Food Aid

In 1986-87, coarse grains (mostly maize but also barley, sorghum, and millet) constituted only around 10% of food aid, but by 1991-92 their share had risen to over 30%, or 4.2 million tons. During the same period, wheat's percentage contribution fell from over 80% to a little over 60%. The distribution of maize food aid among developing countries has changed as well. Although absolute levels of maize food aid have increased in Africa since 1986-87, when Africa received over 70% of global maize food aid, in 1990-91 its share was only 36%. Latin America has maintained its 18% share of maize food aid over this period, while Asia has seen the greatest increase, from less than 10% in 1986-87 to about 16% in 1990-91. During its difficult transition to a free market system, the FSU has also received considerable maize donations (more than 2 million tons from the US alone). As the FSU's policy changes begin to take effect and its grain market becomes more efficient, the amount of maize food aid supplied to the FSU should decline.

China's Present and Future Role in the World Maize Trade

Although China was forced to import maize during part of 1990, its maize exports climbed to 9.3 million tons in 1991, 11.5 in 1992, and 12.5 in 1993 (USDA 1994), partly because of its proximity to some of the world's largest maize importers. China's principal trading partners include the FSU and the countries of East Asia, particularly South Korea, Japan, Malaysia, and Taiwan via Hong Kong. Throughout the 1980s, trade in East Asia expanded rapidly, which drove up Chinese maize exports.

Several developments explain the increase in domestic and international supply. China's maize breeding program has enabled farmers to raise their maize yields steadily since the 1960s (Zhang Shi-huang n.d.). During 1981-92, production rose by 4.6%/yr, owing to an increase in yields of 3.2% and an expansion of maize area of 1.4%. State governments implemented changes in agricultural policies, including production supports and subsidies for fertilizers, pesticides, and seed. Farmers now participate in open markets and the state's role in grain procurement is declining.

China's present export status depends, in part, on its ability to meet its domestic demand for maize. The World Bank projects real incomes to continue growing at 5.7% annually for the rest of this decade. By 2005, demand for maize may reach 161 million tons for feed and 28 million tons for food, implying an annual increase in consumption of 7.1% and 1.1 %, respectively, beginning in 1990. Increased domestic production or reduced exports will therefore be needed to meet the rising demand.

The Effects of NAFTA on the Mexican Maize Economy

Changes in agricultural policies in Mexico and the signing of NAFTA are predicted to bring about a decline in domestic maize production and raise imports. The Mexican government has created a new system of subsidies, called PROCAMPO, in which direct producer subsidies (paid by the hectare) will replace the current system of guaranteed producer prices. The new system will be implemented over a period of 15 years. Beginning in 1995, the reference price for Mexican maize producers will be the international price.

Under NAFTA, Mexico may import a minimum annual quota of tariff-free maize from the US; when imports exceed this quota, Mexico may apply a tariff in accordance with

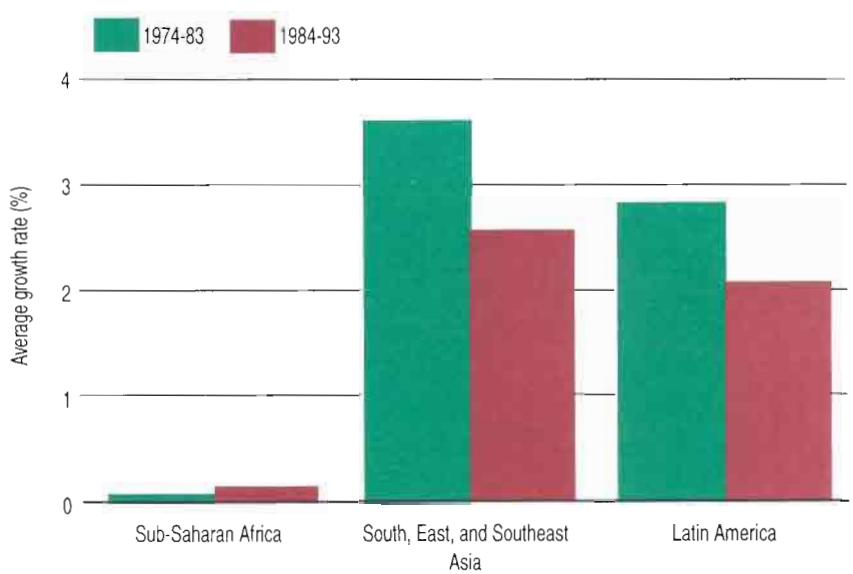


Figure 13. Growth rates in maize yield in developing countries, 1974-93.

a base rate. In 1994, the quota was 2.5 million tons; beginning in 1995, it will increase by 3% each year. The tariff will be reduced in 15 annual steps and eventually eliminated. By the year 2008 the quota will have been expanded to 3.78 million tons, and the tariff rate will have been set to zero.

Various studies project that Mexican maize production will decline from 4% to 20% and import levels will rise from 25% to 106% in the first five years after NAFTA's enactment (see, for example, Hueth, O'Mara, and Just 1993, Burfisher, House, and Langley 1992, Krissoff, Neff, and Sharples 1992, Robinson et al. 1992, and Peterson 1991). Declining production and higher imports probably will affect consumption, which is strictly fixed for a portion of the population. By the end of 1994 — the first full year that changes in subsidies and the effects of NAFTA are felt in the agricultural sector — it will be more evident how maize production and trade will be affected by the recent sweeping changes in Mexican agricultural policy.

Former Soviet Union: Projections on Production and Imports

Shifting consumer prices and land privatization have not spurred maize production in the FSU as expected, and production has fallen to pre-1980 levels (USDA 1992). But the level of production is not the main problem. The high cost of production, covered in the past by the central government, presents a serious challenge to collective and state farms. Procurement poses another problem, particularly for grain-deficit areas. State and collective farms maintain grain stocks as an inflation hedge rather than selling them to national procurement agents. As the value of the ruble declines, grain becomes more valuable, especially in barter trades.

Throughout the FSU, maize is used mostly as feed. Skyrocketing meat and milk prices have led to a decline in demand; more livestock are being slaughtered, decreasing future feed grain demand. The shortage of feed grain available through the national procurement agency also contributes to the livestock sector's contraction.

The inability to procure sufficient grain stocks nationally has increased the importance of imports. Credit arrangements and barter trades are the main means the FSU has for securing imports. Some 1-1.5 million tons of maize have been imported from China in exchange for raw materials and machinery. Both the EU and US have extended credit for grain purchases, but the FSU has hesitated to use its complete credit line. Food aid, mainly through the US Food for Progress program, accounted for 2 million tons of maize imported into the FSU.

Several republics still rely on Exportkhleb, the semi-privatized state grain export/import agency. Other importing firms have sprouted up to join the grain market, but state control of hard currency hampers their efforts. In the near future, the possibility of importing grain will continue to be determined by trading partners willing to accept bartered goods or extend credit. Procurement problems also portend continued reliance on imports.

Part 3

Selected Maize Statistics

The tables that follow present 39 statistics related to maize production, prices, trade, consumption, maize seed use and value, as well as some basic economic indicators. The statistics were selected to provide the latest available information.

Countries listed in the tables are classified either as maize producers or consumers. Maize consumers include developing countries consuming over 100,000 tons of maize per year, and developed countries consuming more than one million tons of maize per year. Maize producers include developing countries in which maize production exceeded 100,000 t/yr or accounted for at least 50% of total maize consumption, and developed countries in which maize production exceeded one million tons per year or accounted for 50% of total maize consumption. Average 1990-92 data were used in the classification.

Unless otherwise indicated, the regional aggregates given for each region and presented in the final table include all of the countries of a particular region for which information was available (for a list of countries belonging to each region, see Annex 1). Regional totals were calculated by summing the values for all the countries in a region and then taking the mean value for the time period presented. They thus may not exactly equal the sum of the average values presented for the same time period for each country.

All prices reported in the tables were converted to US dollars at official exchange rates.

Notes on the Variables

The 1992 maize yield data confirm that certain countries in Eastern and Southern Africa, including Malawi, Mozambique, the Republic of South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe, were affected by a severe drought. When 1992 is excluded from the calculation of the 1983-92 trends, the trends in the Malawi, Tanzania, and Zambia yield figures are close to zero, the trend in Mozambique's yields is substantially less negative, the trends for Swaziland and Zimbabwe become positive, and the magnitude of the trend for South Africa nearly triples. In addition to maize yield trends, variables most likely to have been affected include 7, 8, 11-14, and 16-21. Other variables may have been affected to a lesser degree.

Variable 1: The source of this information was the FAO diskette of population statistics (1993).

Variables 2-3: These data were obtained from the World Bank *World Development Report* (1993).

Variables 4, 5, 9-14, 17: The sources of these variables were the FAO diskettes of production statistics (1993) and the FAO *Production Yearbook*, vol. 46 (1992). Growth rates were calculated using the semilog model:

$$\ln Y = a + BX + u,$$

where:

$\ln Y$ = the natural logarithm of variable Y,
X = time period (year), and
B = growth rate of Y.

The function describes a variable, Y, which displays a constant proportional rate of growth ($B > 0$) or decay ($B < 0$).

Variables 6-8, 15, 16: These variables were obtained from the FAO diskettes of Agrostat/PC (1993).

Variables 18-21: These data were obtained from the FAO diskettes of trade statistics (1992), the FAO *Trade Yearbook*, vol. 46. (1992), and the Jan. 1994 issue of *Grain: World Markets and Trade* (USDA, FAS). Net imports were calculated as imports minus exports. Negative numbers indicate that the country is a net exporter. Consumption was calculated as production plus net imports. Growth rates were calculated using the formula given above.

Variables 22-23: The source of these variables was the FAO diskettes of food balance sheets regarding utilization (1992). Percentages may not sum to 100 due to other uses, i.e., seed, wastage, and industrial use, which are not included in the tables.

Variables 24-39: These data were collected through a general country survey of knowledgeable maize scientists. Data for the majority of the countries refer to the maize crop harvested in 1992, although in some cases 1993 is the reference year. The maize price is the average post-harvest price received by farmers. The nitrogen price is usually the price paid by farmers for the most common nitrogenous fertilizer (usually urea). The source for the 1985 data is the *1986 CIMMYT World Maize Facts and Trends* (CIMMYT 1987). Some data were estimated by CIMMYT staff.

Eastern and Southern Africa

		Producers					
		Angola	Burundi	Ethiopia	Kenya	Lesotho	Madagascar
General indicators	1. Estimated population, 1993 (million)	10.3	6.0	54.6	26.0	1.9	13.2
	2. Estimated growth rate of population, 1991-2000 (%/year)	..	2.9	2.7	3.5	2.4	2.8
	3. Per capita income, 1991 (US$)	..	210	120	340	580	210
	4. Per capita cereal production, 1990-92 (kg/yr)	36	53	130	114	86	207
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-1.6	0.6	1.2	0.8	-2.3	3.0
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	750	124	1,000	1,428	104	153
	7. Maize yield, 1990-92 (t/ha)	0.4	1.4	1.6	1.7	1.2	1.0
	8. Maize production, 1990-92 (000 t)	283	173	1,605	2,397	114	155
	9. Growth rate of maize area, 1973-82 (%/yr)	0.1	1.4	-0.5	-2.3	0.5	1.6
	10. Growth rate of maize area, 1983-92 (%/yr)	3.3	-0.6	1.6	2.1	-1.4	2.1
	11. Growth rate of maize yield, 1973-82 (%/yr)	-6.4	0.0	5.2	2.4	2.8	-1.4
	12. Growth rate of maize yield, 1983-92 (%/yr)	2.7	2.8	1.7	0.4	4.6	-0.3
	13. Growth rate of maize production, 1973-82 (%/yr)	-6.3	1.5	4.7	0.1	3.3	0.2
	14. Growth rate of maize production, 1983-92 (%/yr)	0.6	2.2	3.3	2.4	3.2	1.7
	15. Maize area as percentage of total cereal area, 1990-92	83	57	19	80	70	12
	16. Average yield of all cereals, 1990-92 (t/ha)	0.4	1.4	1.3	1.6	1.1	2.0
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	-2.6	3.3	3.0	-3.2	4.8	-1.6
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	88	0	0	94	57	-6
	19. Net imports of maize per capita, 1990-92 (kg/yr)	9	0	0	4	31	0
	20. Per capita total maize consumption, 1990-92 (kg/yr)	36	31	32	100	94	12
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-2.2	-0.7	0.6	-1.2	3.1	1.8
	22. Percent maize used for animal feed, 1988-90 (%)	2	2	0	1	1	5
	23. Percent maize used for direct human consumption, 1988-90 (%)	86	90	94	93	93	85
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	..	20	17	84	90	..
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)		..	..	66	..	..
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	..	0	4	74	80	..
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)		.	..	61	..	..
	28. Amount of all maize seed planted, 1992 (000 t)		3.5	28.0	29.6	2.5	..
	29. Amount of commercial maize seed planted, 1992 (000 t)	..	0.1	2.8	21.6	1.9	..
	30. Amount of hybrid seed planted, 1992 (000 t)	.	0.0	1.0	20.7	1.8	..
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	..	0	64	100	0	.
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992		1.3	2.5	6.3	5.7	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..		3.5	6.3	..	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	.	..	11.4	6.3	13.9	..
	35. Value of all commercial seed used, 1992 (million US$)	.	0.0	1.3	18.2	3.4	..
	36. Value of all hybrid seed used, 1992 (million US$)	..	0.0	0.8	17.4	3.3	..
Prices	37. Farm price of maize, 1992 (US$/t)		126	119	133	132	.
	38. Ratio of farm level nitrogen price to maize price, 1992	.	7.2	1.9	8.1	4.8	..
	39. Farm wage in kg of maize per day, 1992	.	4.0	2.9	6.0	12.6	..

Eastern and Southern Africa (continued)

		Producers					
		Malawi*	Mozambique*	Namibia	Rwanda	Somalia	Swaziland*
General indicators	1. Estimated population, 1993 (million)	10 7	15.3	1.6	7.8	9.5	0.8
	2. Estimated growth rate of population, 1991-2000 (%/year)	3 1	2.9	3.2	2.3		
	3. Per capita income, 1991 (US$)	230	80	1.460	270	.	..
	4. Per capita cereal production, 1990-92 (kg/yr)	140	32	52	42	45	123
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-6.5	-9 3	-7.4	-3 6	-8.5	-2.7
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	1.365	952	107	76	158	76
	7. Maize yield, 1990-92 (t/ha)	0.9	0.3	0 4	1.2	1.1	1.2
	8. Maize production, 1990-92 (000 t)	1.197	304	43	96	172	96
	9. Growth rate of maize area, 1973-82 (%/yr)	0.5	1.5	0 4	3.0	8.8	-2.5
	10. Growth rate of maize area, 1983-92 (%/yr)	2.2	1 6	0.3	-0.9	-6.9	2 0
	11. Growth rate of maize yield, 1973-82 (%/yr)	1 0	-3 8	1.1	1.9	-3.3	-1.7
	12. Growth rate of maize yield, 1983-92 (%/yr)	-5.3	-6 9	-6 4	0.9	-1.6	-1.0
	13. Growth rate of maize production, 1973-82 (%/yr)	1 4	-2.3	1.6	5.0	5.5	-4.2
	14. Growth rate of maize production, 1983-92 (%/yr)	-3.1	-5.4	-6.1	0.0	-8.6	0.9
	15. Maize area as percentage of total cereal area, 1990-92	95	63	52	31	28	98
	16. Average yield of all cereals, 1990-92 (t/ha)	0.9	0.3	0 4	1.3	0.6	1.3
	17 Growth rate of yield of all cereals, 1983-92 (%/yr)	-5 1	-8.2	-4 0	0.8	-2.1	-1 0
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	222	501	39	2	10	18
	19. Net imports of maize per capita, 1990-92 (kg/yr)	24	31	21	0	1	22
	20. Per capita total maize consumption, 1990-92 (kg/yr)	157	50	45	14	24	139
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-2.0	3 4	-2.3	-3.2	-13.2	-3.5
	22. Percent maize used for animal feed, 1988-90 (%)	3	0	0	0	0	42
	23. Percent maize used for direct human consumption, 1988-90 (%)	87	92	95	85	91	42
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	26	65		3	.	..
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	26	.	..	..	.	..
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	24	4	..	0	..	..
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	0		..		.	..
	28. Amount of all maize seed planted, 1992 (000 t)	35 1	21 7	..	2.0	..	..
	29. Amount of commercial maize seed planted, 1992 (000 t)	8 5	13.2		0.0	..	..
	30. Amount of hybrid seed planted, 1992 (000 t)	8.5	0.6		0.0		..
	31 Percentage of hybrid maize seed that is of public origin, 1992 (%)	42	0	..	0	..	..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992		5 0	.	3.7	.	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	8 1	..	..	.		..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	8.0	7.1	.	..	..	..
	35. Value of all commercial seed used, 1992 (million US$)	7.2	5.7	..	0.0	..	..
	36. Value of all hybrid seed used, 1992 (million US$)	7.2	0.4	..	0.0	..	..
Prices	37 Farm price of maize, 1992 (US$/t)	102	60	..	161	..	..
	38. Ratio of farm level nitrogen price to maize price, 1992	6 4	4.3	..	6.8	.	..
	39. Farm wage in kg of maize per day, 1992	5.0	4.0		4 4	..	..

* These countries experienced a severe drought in 1992 which substantially affected their maize yields. Please see Notes on the Variables.

Eastern and Southern Africa (continued)

		Producers				Regional Total or Average
		Tanzania*	Uganda	Zambia*	Zimbabwe*	
General indicators	1. Estimated population, 1993 (million)	28.8	19.2	8.9	10.9	255.6
	2. Estimated growth rate of population, 1991-2000 (%/year)	3.0	3.3	3	2.3	3.2
	3. Per capita income, 1991 (US$)	100	170	..	650	228
	4. Per capita cereal production, 1990-92 (kg/yr)	131	81	116	173	116
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-1.2	1.0	-4.2	-7.3	-0.7
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	1,796	421	681	1,044	9,588
	7. Maize yield, 1990-92 (t/ha)	1.3	1.4	1.3	1.2	1.2
	8. Maize production, 1990-92 (000 t)	2,334	571	884	1,314	11,523
	9. Growth rate of maize area, 1973-82 (%/yr)	2.7	-5.2	-10.9	4.3	-0.3
	10. Growth rate of maize area, 1983-92 (%/yr)	3.8	4.6	3.8	-3.6	1.5
	11. Growth rate of maize yield, 1973-82 (%/yr)	5.3	1.1	6.9	-0.9	2.0
	12. Growth rate of maize yield, 1983-92 (%/yr)	-0.2	2.1	-5.6	-1.3	2.0
	13. Growth rate of maize production, 1973-82 (%/yr)	8.1	-4.1	-4.0	3.4	1.7
	14. Growth rate of maize production, 1983-92 (%/yr)	3.5	6.7	-1.8	-4.9	0.9
	15. Maize area as percentage of total cereal area, 1990-92	61	38	84	73	39
	16. Average yield of all cereals, 1990-92 (t/ha)	1.3	1.4	1.3	1.1	1.1
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	-0.4	1.1	-5.1	-0.5	1.3
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	-16	-25	254	24	1,357
	19. Net imports of maize per capita, 1990-92 (kg/yr)	-1	-1	28	0	6
	20. Per capita total maize consumption, 1990-92 (kg/yr)	82	28	130	133	55
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-1.3	3.3	-2.1	1.2	-0.8
	22. Percent maize used for animal feed, 1988-90 (%)	10	3	4	19	6
	23. Percent maize used for direct human consumption, 1988-90 (%)	82	80	87	67	85
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	19	40	70	100	48
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	12	36	64	77	36
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	6	5	65	100	34
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	5	1	53	60	25
	28. Amount of all maize seed planted, 1992 (000 t)	55.3	11.3	17.6	17.8	224.5
	29. Amount of commercial maize seed planted, 1992 (000 t)	2.7	1.0	10.8	17.8	80.4
	30. Amount of hybrid seed planted, 1992 (000 t)	1.7	0.4	10.5	17.8	63.1
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	60	100	95	66	..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	5.5	6.1	3.0	..	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	8.4	13.0	4.0	4.2	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	10.0	..	4.4	4.2	..
	35. Value of all commercial seed used, 1992 (million US$)	2.3	0.7	5.4	10.5	54.7
	36. Value of all hybrid seed used, 1992 (million US$)	1.6	0.4	5.2	10.5	46.9
Prices	37. Farm price of maize, 1992 (US$/t)	138	77	123	138	..
	38. Ratio of farm level nitrogen price to maize price, 1992	6.1	48.3	6.3	3.2	..
	39. Farm wage in kg of maize per day, 1992	3.5	5.6	6.3	10.0	..

* These countries experienced a severe drought in 1992 which substantially affected their maize yields. Please see Notes on the Variables.

West and Central Africa

		Producers						
		Benin	Burkina Faso	Cameroon	Côte d'Ivoire	Ghana	Guinea	Mali
General indicators	1. Estimated population, 1993 (million)	5.0	9.8	12.5	13.4	16.6	6.3	10.1
	2. Estimated growth rate of population, 1991-2000 (%/year)	2.9	3.0	3.1	3.3	3.2	2.9	3.1
	3. Per capita income, 1991 (US$)	380	290	850	690	400	460	280
	4. Per capita cereal production, 1990-92 (kg/yr)	117	226	75	99	70	155	222
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	0.7	4.9	-1.4	-0.4	4.7	1.1	2.9
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	413	201	220	675	525	90	172
	7. Maize yield, 1990-92 (t/ha)	1.0	1.5	1.8	0.8	1.3	0.9	1.3
	8. Maize production, 1990-92 (000 t)	413	294	400	517	688	84	224
	9. Growth rate of maize area, 1973-82 (%/yr)	-1.5	-2.4	-1.8	3.4	0.3	6.1	-7.4
	10. Growth rate of maize area, 1983-92 (%/yr)	1.4	7.4	-4.2	2.5	0.2	9.4	6.6
	11. Growth rate of maize yield, 1973-82 (%/yr)	5.0	9.8	0.0	6.8	-1.8	-2.1	6.5
	12. Growth rate of maize yield, 1983-92 (%/yr)	1.3	9.7	4.1	1.8	8.1	-1.8	0.9
	13. Growth rate of maize production, 1973-82 (%/yr)	3.5	7.4	-1.8	3.5	-1.5	4.0	-0.9
	14. Growth rate of maize production, 1983-92 (%/yr)	2.7	17.1	-0.1	-0.7	8.3	7.6	7.5
	15. Maize area as percentage of total cereal area, 1990-92	70	7	27	49	52	8	7
	16. Average yield of all cereals, 1990-92 (t/ha)	0.9	0.8	1.1	0.9	1.1	0.8	0.9
	17 Growth rate of yield of all cereals, 1983-92 (%/yr)	2.5	3.8	1.3	-0.1	7.4	-1.2	0.3
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	2	8	15	-12	15	0	3
	19. Net imports of maize per capita, 1990-92 (kg/yr)	0	1	1	-1	1	0	0
	20. Per capita total maize consumption, 1990-92 (kg/yr)	87	33	34	38	45	14	24
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-0.6	12.2	-2.9	-2.9	3.3	-5.1	-0.1
	22. Percent maize used for animal feed, 1988-90 (%)	3	0	1	11	6	0	0
	23. Percent maize used for direct human consumption, 1988-90 (%)	67	91	89	66	79	65	91
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	8	10	35	26	35	..	20
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	..	..	30	10	30	..	..
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	0	0	5	2	0	..	0
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)			0	0	0	..	..
	28. Amount of all maize seed planted, 1992 (000 t)	11.9	5.4	5.1	18.8	12.4	..	4.4
	29. Amount of commercial maize seed planted, 1992 (000 t)	0.2	0.2	0.5	3.3	0.5	..	0.1
	30. Amount of hybrid seed planted, 1992 (000 t)	0.0	0.0	0.2	0.3	0.0	..	0.0
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	0	0	0.5	75	0	..	0
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	2.1	4.0	6.5	8.9	4.2	..	2.5
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..	..	10.0	18.0	..	..	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..	..	13.3	19.0	..	..	..
	35. Value of all commercial seed used, 1992 (million US$)	0.1	0.1	0.7	4.8	0.3	..	0.1
	36. Value of all hybrid seed used, 1992 (million US$)	0.0	0.0	0.5	0.4	0.0	..	0.0
Prices	37. Farm price of maize, 1992 (US$/t)	192	124	167	167	135	..	160
	38. Ratio of farm level nitrogen price to maize price, 1992	6.8	6.8	7.0	4.5	11.4	..	7.1
	39. Farm wage in kg of maize per day, 1992	8.0	26.0	18.0	12.9	9.1	..	12.5

West and Central Africa
(continued)

		Producers					Regional Total or Average
		Niger	Nigeria	Senegal	Togo	Zaire	
General indicators	1. Estimated population, 1993 (million)	8.3	119.3	7.9	3.9	41.2	279.8
	2. Estimated growth rate of population, 1991-2000 (%/year)	3.5	2.8	2.8	3.1	..	2.9
	3. Per capita income, 1991 (US$)	300	340	720	410	..	426
	4. Per capita cereal production, 1990-92 (kg/yr)	259	117	123	129	37	107
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	1.5	0.4	0.6	1.4	0.4	0.8
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	5	1,517	104	270	1,243	6,456
	7. Maize yield, 1990-92 (t/ha)	0.7	1.2	1.1	0.9	0.7	1.0
	8. Maize production, 1990-92 (000 t)	4	1,811	117	252	899	6,172
	9. Growth rate of maize area, 1973-82 (%/yr)	10.9	-9.3	7.4	5.6	2.2	-0.1
	10. Growth rate of maize area, 1983-92 (%/yr)	-10.0	3.5	3.0	3.1	5.5	2.7
	11. Growth rate of maize yield, 1973-82 (%/yr)	0.5	2.5	0.6	-2.3	1.9	-0.4
	12. Growth rate of maize yield, 1983-92 (%/yr)	1.5	1.8	0.8	2.9	-1.9	1.5
	13. Growth rate of maize production, 1973-82 (%/yr)	11.4	-6.7	7.9	3.3	4.1	-0.5
	14. Growth rate of maize production, 1983-92 (%/yr)	-8.5	5.3	3.8	6.1	3.6	4.1
	15. Maize area as percentage of total cereal area, 1990-92	0	14	9	44	70	19
	16. Average yield of all cereals, 1990-92 (t/ha)	0.3	1.2	0.8	0.8	0.8	0.9
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	-0.6	-3.7	3.0	-0.4	-1.4	-0.9
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	4	3	18	1	37	225
	19. Net imports of maize per capita, 1990-92 (kg/yr)	0	0	2	0	1	1
	20. Per capita total maize consumption, 1990-92 (kg/yr)	1	16	18	70	25	23
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-25.1	1.4	1.0	3.0	-0.9	0.3
	22. Percent maize used for animal feed, 1988-90 (%)	0	5	8	0	2	5
	23. Percent maize used for direct human consumption, 1988-90 (%)	95	81	84	76	88	80
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	..	25	98	10	..	21
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	..	40	30	..	..	22
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	..	3	0	1	..	1
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	..	2	0	3	..	1
	28. Amount of all maize seed planted, 1992 (000 t)	..	37.1	2.8	7.8	..	105.6
	29. Amount of commercial maize seed planted, 1992 (000 t)	..	2.5	0.2	0.2	..	7.6
	30. Amount of hybrid seed planted, 1992 (000 t)	..	0.7	0.0	0.1	..	1.2
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	..	56	0	100	..	..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	..	2.7	2.7	3.9	..	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..	7.8	..	3.9	.	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..	10.0	..	..	..	..
	35. Value of all commercial seed used, 1992 (million US$)	..	1.6	0.2	0.1	..	7.6
	36. Value of all hybrid seed used, 1992 (million US$)	..	0.8	0.0	0.0	..	1.4
Prices	37. Farm price of maize, 1992 (US$/t)	..	158	360	107	..	..
	38. Ratio of farm level nitrogen price to maize price, 1992	..	3.0	7.2	3.6	..	..
	39. Farm wage in kg of maize per day, 1992	..	11.1	17.8	18.3	..	..

		North Africa	Producers		Consumers			Regional Total or Average
			Egypt	Morocco	Algeria	Libya	Tunisia	
General indicators	1.	Estimated population, 1993 (million)	56.0	27.0	27.0	5.0	8.6	123.7
	2.	Estimated growth rate of population, 1991-2000 (%/year)	2.1	2.2	2.7	..	1.9	2.2
	3.	Per capita income, 1991 (US$)	610	1,030	1,980	..	1,500	1,082
	4.	Per capita cereal production, 1990-92 (kg/yr)	258	233	109	61	255	212
	5.	Growth rate of per capita cereal production, 1983-92 (%/yr)	4.3	0.7	3.6	-4.5	4.1	3.4
Production of maize and all cereals	6.	Maize area harvested, 1990-92 (000 ha)	857	404	5	1	..	1,263
	7.	Maize yield, 1990-92 (t/ha)	5.9	0.8	0.4	1.0	..	4.3
	8.	Maize production, 1990-92 (000 t)	5,049	329	2	1	..	5,381
	9.	Growth rate of maize area, 1973-82 (%/yr)	1.4	-2.1	..	..	..	0.1
	10.	Growth rate of maize area, 1983-92 (%/yr)	1.2	0.2	..	..	..	0.9
	11.	Growth rate of maize yield, 1973-82 (%/yr)	1.6	-4.1	..	..	.	2.2
	12.	Growth rate of maize yield, 1983-92 (%/yr)	3.6	1.5	..	..	..	3.8
	13.	Growth rate of maize production, 1973-82 (%/yr)	3.0	-6.2	..	..	..	2.3
	14.	Growth rate of maize production, 1983-92 (%/yr)	4.8	1.7	..	..	..	4.7
	15.	Maize area as percentage of total cereal area, 1990-92	36	8	0	0	..	10
	16.	Average yield of all cereals, 1990-92 (t/ha)	5.7	1.1	0.9	0.7	1.4	2.0
	17.	Growth rate of yield of all cereals, 1983-92 (%/yr)	3.6	1.4	4.5	0.4	8.5	4.5
Trade and utilization	18.	Net imports of maize , 1990-92 (000 t)	1,547	189	906	118	292	3,051
	19.	Net imports of maize per capita, 1990-92 (kg/yr)	29	7	35	26	35	26
	20.	Per capita total maize consumption, 1990-92 (kg/yr)	123	20	35	26	35	71
	21.	Growth rate of per capita maize consumption, 1983-92 (%)	0.6	-0.8	7.1	-6.2	0.9	0.9
	22.	Percent maize used for animal feed, 1988-90 (%)	37	14	91	93	97	47
	23.	Percent maize used for direct human consumption, 1988-90 (%)	51	72	2	2	0	42
Maize seed use and value	24.	Area planted to improved maize as a percentage of total maize area, 1992 (%)	35	5	..	..	..	24
	25.	Area planted to improved maize as a percentage of total maize area, 1985 (%)	64	..	..	..	..	49
	26.	Area planted to hybrids as a percentage of total maize area, 1992 (%)	28	5	..	..	..	20
	27.	Area planted to hybrids as a percentage of total maize area, 1985 (%)	10	..	..	..	..	7
	28.	Amount of all maize seed planted, 1992 (000 t)	30.5	16.0	..	..	..	46.5
	29.	Amount of commercial maize seed planted, 1992 (000 t)	8.7	0.5	..	.	..	9.2
	30.	Amount of hybrid seed planted, 1992 (000 t)	8.4	0.5	..	..	.	8.9
	31.	Percentage of hybrid maize seed that is of public origin, 1992 (%)	76	9	..	..	..	..
	32.	Ratio of the price of commercial OPV seed to the price of grain, 1992	3.0	..	..	..	..	..
	33.	Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	8.8	2.5	..	..	..	..
	34.	Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	17.5	7.4	..	..	..	..
	35.	Value of all commercial seed used, 1992 (million US$)	10.7	1.1	..	..	..	11.8
	36.	Value of all hybrid seed used, 1992 (million US$)	10.6	1.1	..	..	..	11.7
Prices	37.	Farm price of maize, 1992 (US$/t)	149	290	..	..	..	..
	38.	Ratio of farm level nitrogen price to maize price, 1992	2.2	1.7	..	..	..	..
	39.	Farm wage in kg of maize per day, 1992	10.0	13.1	..	..	..	..

West Asia

		Producers				
		Afghanistan	Iran	Iraq	Syria	Turkey
General indicators	1. Estimated population, 1993 (million)	20.5	63.2	19.9	13 8	59.6
	2. Estimated growth rate of population, 1991-2000 (%/year)	..	3.4	..	3.4	1.9
	3. Per capita income, 1991 (US$)	..	2,170	..	1,160	1,780
	4. Per capita cereal production, 1990-92 (kg/yr)	150	267	128	275	529
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-6.3	2.4	-1.7	2.1	-0.5
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	248	43	82	63	515
	7. Maize yield, 1990-92 (t/ha)	1.6	4.0	2.2	3.3	4.1
	8. Maize production, 1990-92 (000 t)	400	169	190	207	2,127
	9. Growth rate of maize area, 1973-82 (%/yr)	-1.7	2.0	8.5	5.6	-0.7
	10. Growth rate of maize area, 1983-92 (%/yr)	-5.8	13.5	20.6	9.7	-1.2
	11. Growth rate of maize yield, 1973-82 (%/yr)	0.4	-4.3	0.6	5.7	2.1
	12. Growth rate of maize yield, 1983-92 (%/yr)	-0.9	5.5	1.6	10.7	4.6
	13. Growth rate of maize production, 1973-82 (%/yr)	-1.3	-2.3	9.1	11.3	1.3
	14. Growth rate of maize production, 1983-92 (%/yr)	-6.7	19.0	22.2	20.4	3.4
	15. Maize area as percentage of total cereal area, 1990-92	11	0	3	2	4
	16. Average yield of all cereals, 1990-92 (t/ha)	1.2	1.6	0.8	0.9	2.2
	17 Growth rate of yield of all cereals, 1983-92 (%/yr)	-2.2	3.9	-1.4	0.5	1.5
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	0	969	138	224	232
	19. Net imports of maize per capita, 1990-92 (kg/yr)	0	17	7	17	4
	20. Per capita total maize consumption, 1990-92 (kg/yr)	23	20	17	33	41
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-9.1	-0.3	-3.1	4.9	2.2
	22. Percent maize used for animal feed, 1988-90 (%)	10	90	96	88	44
	23. Percent maize used for direct human consumption, 1988-90 (%)	82	6	0	8	43
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	..	..	..	95	31
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	.	..	..	100	46
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	..	.	..	0	30
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	..	.	..	88	33
	28. Amount of all maize seed planted, 1992 (000 t)	..	..	..	2.0	17.6
	29. Amount of commercial maize seed planted, 1992 (000 t)	..		..	1.9	4.3
	30. Amount of hybrid seed planted, 1992 (000 t)	..	..	..	0.0	4.3
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	..	..	..	..	1
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	..	..	..	4.3	3.3
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992		..	..	..	8.9
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..	..	..	..	16.7
	35. Value of all commercial seed used, 1992 (million US$)	.	..	..	1.4	12.0
	36. Value of all hybrid seed used, 1992 (million US$)	..	..	..	0.0	12.0
Prices	37. Farm price of maize, 1992 (US$/t)	..	..	..	166	178
	38. Ratio of farm level nitrogen price to maize price, 1992	..	..	..	3.0	1.0
	39. Farm wage in kg of maize per day, 1992	..	..	..	9.3	40.0

West Asia
(continued)

		Consumers			Regional Total or Average
		Jordan	Lebanon	Saudi Arabia	
General indicators	1. Estimated population, 1993 (million)	4.7	2.9	16.5	220.6
	2. Estimated growth rate of population, 1991-2000 (%/year)	4.0	..	3.5	2.9
	3. Per capita income, 1991 (US$)	1,050	..	7,820	2,377
	4. Per capita cereal production, 1990-92 (kg/yr)	37	29	306	293
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	0.2	24.1	13.1	0.5
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	1	2	3	1,001
	7. Maize yield, 1990-92 (t/ha)	2.8	1.5	1.7	3.2
	8. Maize production, 1990-92 (000 t)	4	3	4	3,169
	9. Growth rate of maize area, 1973-82 (%/yr)	..	..	..	-0.7
	10. Growth rate of maize area, 1983-92 (%/yr)	..	..	.	-0.7
	11. Growth rate of maize yield, 1973-82 (%/yr)	..	..		1.4
	12. Growth rate of maize yield, 1983-92 (%/yr)	..	..	..	4.0
	13. Growth rate of maize production, 1973-82 (%/yr)	..	..	..	0.7
	14. Growth rate of maize production, 1983-92 (%/yr)	..	..	..	3.3
	15. Maize area as percentage of total cereal area, 1990-92	1	5	0	3
	16. Average yield of all cereals, 1990-92 (t/ha)	1.0	2.0	4.5	1.7
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	3.9	13.0	5.0	2.0
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	409	119	571	2,792
	19. Net imports of maize per capita, 1990-92 (kg/yr)	119	43	38	14
	20. Per capita total maize consumption, 1990-92 (kg/yr)	120	45	39	30
	21. Growth rate of per capita maize consumption, 1983-92 (%)	8.5	6.1	-6.8	-0.1
	22. Percent maize used for animal feed, 1988-90 (%)	98	95	90	65
	23. Percent maize used for direct human consumption, 1988-90 (%)	0	3	6	27
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	..	..	..	39
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	..	..	..	44
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	..	..	..	27
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	..	..	..	23
	28. Amount of all maize seed planted, 1992 (000 t)	..		.	19.6
	29. Amount of commercial maize seed planted, 1992 (000 t)				6.2
	30. Amount of hybrid seed planted, 1992 (000 t)	..	..	..	4.3
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	..	..		..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	..	..	..	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..	..	..	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..	..	.	..
	35. Value of all commercial seed used, 1992 (million US$)	..	..	..	13.4
	36. Value of all hybrid seed used, 1992 (million US$)			..	12.0
Prices	37. Farm price of maize, 1992 (US$/t)	.	..	.	..
	38. Ratio of farm level nitrogen price to maize price, 1992	..	..	..	..
	39. Farm wage in kg of maize per day, 1992	..	..		..

South Asia		Producers				Regional Total or Average
		India	Myanmar	Nepal	Pakistan	
General indicators	1. Estimated population, 1993 (million)	896.6	44.6	21.0	128.0	1232.1
	2. Estimated growth rate of population, 1991-2000 (%/year)	1.8	..	2.5	2.8	1.9
	3. Per capita income, 1991 (US$)	330	..	180	400	500
	4. Per capita cereal production, 1990-92 (kg/yr)	225	332	274	169	224
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	0.5	-3.0	0.6	-1.3	0.1
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	5,981	136	747	860	7,803
	7. Maize yield, 1990-92 (t/ha)	1.5	1.5	1.6	1.4	1.5
	8. Maize production, 1990-92 (000 t)	9,171	208	1,200	1,222	11,876
	9. Growth rate of maize area, 1973-82 (%/yr)	-0.3	7.8	0.8	2.9	0.2
	10. Growth rate of maize area, 1983-92 (%/yr)	0.4	-3.9	4.1	1.0	0.6
	11. Growth rate of maize yield, 1973-82 (%/yr)	1.6	8.9	-2.5	0.3	1.2
	12. Growth rate of maize yield, 1983-92 (%/yr)	2.5	-1.6	1.5	1.6	2.1
	13. Growth rate of maize production, 1973-82 (%/yr)	1.2	16.7	-1.7	3.2	1.4
	14. Growth rate of maize production, 1983-92 (%/yr)	2.9	-5.4	5.7	2.6	2.8
	15. Maize area as percentage of total cereal area, 1990-92	6	3	26	7	6
	16. Average yield of all cereals, 1990-92 (t/ha)	1.9	2.7	1.9	1.8	2.0
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	3.1	-0.8	1.4	1.7	2.7
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	0	-28	0	9	25
	19. Net imports of maize per capita, 1990-92 (kg/yr)	0	-1	0	0	0
	20. Per capita total maize consumption, 1990-92 (kg/yr)	11	4	61	10	10
	21. Growth rate of per capita maize consumption, 1983-92 (%)	0.8	-8.1	3.3	-0.8	0.6
	22. Percent maize used for animal feed, 1988-90 (%)	2	41	9	20	5
	23. Percent maize used for direct human consumption, 1988-90 (%)	78	52	74	58	75
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	36	..	5	31	32
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	36	..	..	28	34
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	11	..	<1	3	9
	27 Area planted to hybrids as a percentage of total maize area, 1985 (%)	13	..	..	2	11
	28. Amount of all maize seed planted, 1992 (000 t)	208.3	..	25.5	30.7	264.6
	29. Amount of commercial maize seed planted, 1992 (000 t)	32.0	..	0.1	2.1	34.2
	30. Amount of hybrid seed planted, 1992 (000 t)	23.0	..	0.0	0.9	23.9
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	44	..	0	7	..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	3.3	..	2.0	2.1	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	4.7	..	..	4.3	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	8.0	..	7.5	9.3	..
	35. Value of all commercial seed used, 1992 (million US$)	17.6	..	0.0	1.2	18.9
	36. Value of all hybrid seed used, 1992 (million US$)	14.7	..	0.0	0.9	15.7
Prices	37. Farm price of maize, 1992 (US$/t)	97	..	80	117	..
	38. Ratio of farm level nitrogen price to maize price, 1992	2.0	..	3.0	3.4	..
	39. Farm wage in kg of maize per day, 1992	10.0	..	6.3	11.4	..

Southeast Asia and the Pacific

		Producers			
		Indonesia	Kampuchea	Philippines	Thailand
General indicators	1. Estimated population, 1993 (million)	194.6	9.0	66.5	56.9
	2. Estimated growth rate of population, 1991-2000 (%/year)	1.4	..	1.9	1.4
	3. Per capita income, 1991 (US$)	640	..	730	1,570
	4. Per capita cereal production, 1990-92 (kg/yr)	282	280	221	397
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	1.3	1.9	0.4	-2.3
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	3,230	40	3,600	1,453
	7. Maize yield, 1990-92 (t/ha)	2.2	1.3	1.3	2.6
	8. Maize production, 1990-92 (000 t)	6,992	52	4,693	3,708
	9. Growth rate of maize area, 1973-82 (%/yr)	-1.5	3.7	1.3	3.5
	10. Growth rate of maize area, 1983-92 (%/yr)	1.6	-2.0	1.0	-2.1
	11. Growth rate of maize yield, 1973-82 (%/yr)	4.2	-3.7	2.3	-0.2
	12. Growth rate of maize yield, 1983-92 (%/yr)	3.2	3.7	2.9	1.2
	13. Growth rate of maize production, 1973-82 (%/yr)	2.7	0.1	3.6	3.3
	14. Growth rate of maize production, 1983-92 (%/yr)	4.7	1.7	3.8	-0.9
	15. Maize area as percentage of total cereal area, 1990-92	24	2	52	13
	16. Average yield of all cereals, 1990-92 (t/ha)	3.9	1.5	2.0	2.1
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	1.8	3.8	2.1	-0.1
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	21	-4	108	-722
	19. Net imports of maize per capita, 1990-92 (kg/yr)	0	0	2	-13
	20. Per capita total maize consumption, 1990-92 (kg/yr)	37	6	75	53
	21. Growth rate of per capita maize consumption, 1983-92 (%)	2.8	-2.2	0.4	15.1
	22. Percent maize used for animal feed, 1988-90 (%)	26	0	58	95
	23. Percent maize used for direct human consumption, 1988-90 (%)	67	94	29	1
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	44	..	20	100
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	25	..	26	70
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	4	..	10	25
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	1		1	8
	28. Amount of all maize seed planted, 1992 (000 t)	140.3	..	77.7	28.5
	29. Amount of commercial maize seed planted, 1992 (000 t)	9.8	..	6.7	26.1
	30. Amount of hybrid seed planted, 1992 (000 t)	2.2	..	6.1	7.1
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	0	..	31	1
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	7.8	..	3.2	5.5
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..		9.3	14.8
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	14.5	..	10.9	16.7
	35. Value of all commercial seed used, 1992 (million US$)	9.2	..	11.3	23.9
	36. Value of all hybrid seed used, 1992 (million US$)	3.4	..	11.0	12.5
Prices	37. Farm price of maize, 1992 (US$/t)	99	..	167	110
	38. Ratio of farm level nitrogen price to maize price, 1992	2.7	..	2.4	10.2
	39. Farm wage in kg of maize per day, 1992	11.3	..	20.0	21.4

Southeast Asia and the Pacific (continued)

			Producer	Consumers		Regional Total or Average
			Vietnam	Malaysia	Singapore	
General indicators	1.	Estimated population, 1993 (million)	70.9	19.2	2.8	437.2
	2.	Estimated growth rate of population, 1991-2000 (%/year)	..	2.2	1.5	1.6
	3.	Per capita income, 1991 (US$)	..	2,520	14,210	1,218
	4.	Per capita cereal production, 1990-92 (kg/yr)	306	105	0	274
	5.	Growth rate of per capita cereal production, 1983-92 (%/yr)	1.9	-1.2	0.0	0.4
Production of maize and all cereals	6.	Maize area harvested, 1990-92 (000 ha)	437	20	..	8,818
	7.	Maize yield, 1990-92 (t/ha)	1.5	1.7	..	1.8
	8.	Maize production, 1990-92 (000 t)	661	35	..	16,212
	9.	Growth rate of maize area, 1973-82 (%/yr)	5.7	-2.4	..	0.8
	10.	Growth rate of maize area, 1983-92 (%/yr)	2.2	5.1	.	0.7
	11.	Growth rate of maize yield, 1973-82 (%/yr)	-1.0	-9.3		2.3
	12.	Growth rate of maize yield, 1983-92 (%/yr)	1.9	1.8	.	2.3
	13.	Growth rate of maize production, 1973-82 (%/yr)	4.6	-11.7	..	3.1
	14.	Growth rate of maize production, 1983-92 (%/yr)	4.1	6.8	..	2.9
	15.	Maize area as percentage of total cereal area, 1990-92	6	3	..	21
	16.	Average yield of all cereals, 1990-92 (t/ha)	3.1	2.8	..	2.8
	17.	Growth rate of yield of all cereals, 1983-92 (%/yr)	2.4	1.0	..	1.8
Trade and utilization	18.	Net imports of maize , 1990-92 (000 t)	-64	1,583	93	867
	19.	Net imports of maize per capita, 1990-92 (kg/yr)	-1	86	34	2
	20.	Per capita total maize consumption, 1990-92 (kg/yr)	9	88	34	40
	21.	Growth rate of per capita maize consumption, 1983-92 (%)	1.5	3.5	-20.0	3.6
	22.	Percent maize used for animal feed, 1988-90 (%)	20	95	33	53
	23.	Percent maize used for direct human consumption, 1988-90 (%)	74	3	23	39
Maize seed use and value	24.	Area planted to improved maize as a percentage of total maize area, 1992 (%)	60	..	..	45
	25.	Area planted to improved maize as a percentage of total maize area, 1985 (%)	38	..	..	37
	26.	Area planted to hybrids as a percentage of total maize area, 1992 (%)	10	..	..	10
	27	Area planted to hybrids as a percentage of total maize area, 1985 (%)	0	..	.	3
	28.	Amount of all maize seed planted, 1992 (000 t)	14 7		.	261.2
	29.	Amount of commercial maize seed planted, 1992 (000 t)	1.8	.	..	44.3
	30.	Amount of hybrid seed planted, 1992 (000 t)	1.0	..	..	16.3
	31.	Percentage of hybrid maize seed that is of public origin, 1992 (%)	47		..	..
	32.	Ratio of the price of commercial OPV seed to the price of grain, 1992	2.5	.	..	..
	33.	Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	14.5		..	..
	34.	Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	20.0	..	..	..
	35.	Value of all commercial seed used, 1992 (million US$)	1.9	..	..	46.3
	36.	Value of all hybrid seed used, 1992 (million US$)	1.7	..	..	28.5
Prices	37.	Farm price of maize, 1992 (US$/t)	93	..	..	..
	38.	Ratio of farm level nitrogen price to maize price, 1992	3.7	..	..	..
	39.	Farm wage in kg of maize per day, 1992	5.0	..	..	..

		East Asia	Producers		Consumers		Regional Total or Average
			China	Korea D.P.R.	Korea Republic	Taiwan	
General indicators	1.	Estimated population, 1993 (million)	1.205.6	23.0	44.5	.	1275.5
	2.	Estimated growth rate of population, 1991-2000 (%/year)	1.3	..	0.8	..	1.28
	3.	Per capita income, 1991 (US$)	370		6.330		582
	4.	Per capita cereal production, 1990-92 (kg/yr)	346	455	187	..	342
	5.	Growth rate of per capita cereal production, 1983-92 (%/yr)	0.3	-1.7	-2.4	.	0.2
Production of maize and all cereals	6.	Maize area harvested, 1990-92 (000 ha)	21.405	709	23	..	22,138
	7.	Maize yield, 1990-92 (t/ha)	4.5	6.3	4.2		4.6
	8.	Maize production, 1990-92 (000 t)	97,196	4.433	98	..	101,728
	9.	Growth rate of maize area, 1973-82 (%/yr)	1.4	4.5	-1 2	..	1.5
	10.	Growth rate of maize area, 1983-92 (%/yr)	1.9	0.3	-2.5	..	1.9
	11.	Growth rate of maize yield, 1973-82 (%/yr)	3.7	1.9	13.8		3.7
	12.	Growth rate of maize yield, 1983-92 (%/yr)	2.6	-0 4	-0.3	..	2.4
	13.	Growth rate of maize production, 1973-82 (%/yr)	5.1	6.4	12.6		5.2
	14.	Growth rate of maize production, 1983-92 (%/yr)	4.5	-0.1	-2.8	..	4.3
	15.	Maize area as percentage of total cereal area, 1990-92	23	46	2	..	23
	16.	Average yield of all cereals, 1990-92 (t/ha)	4.3	6.5	5.8	..	4.4
	17.	Growth rate of yield of all cereals, 1983-92 (%/yr)	1.6	0.2	0.5	..	1.6
Trade and utilization	18.	Net imports of maize , 1990-92 (000 t)	-1.745	361	6.082	.	4,698
	19.	Net imports of maize per capita, 1990-92 (kg/yr)	-1	16	141	.	4
	20.	Per capita total maize consumption, 1990-92 (kg/yr)	83	216	143		87
	21.	Growth rate of per capita maize consumption, 1983-92 (%)	2 5	-0.7	6.9		2.5
	22.	Percent maize used for animal feed, 1988-90 (%)	57	68	76		59
	23.	Percent maize used for direct human consumption, 1988-90 (%)	33	12	3	.	30
Maize seed use and value	24.	Area planted to improved maize as a percentage of total maize area, 1992 (%)	97	..		100	97
	25.	Area planted to improved maize as a percentage of total maize area, 1985 (%)	72	..	..	96	72
	26.	Area planted to hybrids as a percentage of total maize area, 1992 (%)	90	.	.	90	90
	27.	Area planted to hybrids as a percentage of total maize area, 1985 (%)	72	..	..	92	71
	28.	Amount of all maize seed planted, 1992 (000 t)	737.8	.		2.0	739.8
	29.	Amount of commercial maize seed planted, 1992 (000 t)	688.0			1 8	689.8
	30.	Amount of hybrid seed planted, 1992 (000 t)	664.0	..		1 8	665.8
	31.	Percentage of hybrid maize seed that is of public origin, 1992 (%)	100	..	.	5	..
	32.	Ratio of the price of commercial OPV seed to the price of grain, 1992	1 7	..	..	2.2	..
	33.	Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	4 0		..	7 7	..
	34.	Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..		.	7.7	..
	35.	Value of all commercial seed used, 1992 (million US$)	236.1		..	8 1	244.2
	36.	Value of all hybrid seed used, 1992 (million US$)	232 4		.	8.0	240.4
Prices	37.	Farm price of maize, 1992 (US$/t)	88	..	.	577	..
	38.	Ratio of farm level nitrogen price to maize price, 1992	3.2		..	1 5	..
	39.	Farm wage in kg of maize per day, 1992	7 2	..	..	40.0	.

Mexico, Central America, and the Caribbean

		Producers					
		El Salvador	Guatemala	Haiti	Honduras	Mexico	Nicaragua
General indicators	1. Estimated population, 1993 (million)	5.5	10.0	6.9	5.6	90.0	4.1
	2. Estimated growth rate of population, 1991-2000 (%/year)	2.0	2.9	1.7	2.9	1 9	3.1
	3. Per capita income, 1991 (US$)	1.080	930	370	580	3,030	460
	4. Per capita cereal production, 1990-92 (kg/yr)	158	146	47	130	273	112
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	1.8	-0.9	-7.0	-0.3	-2.2	-3.7
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	303	646	170	410	7,212	205
	7. Maize yield, 1990-92 (t/ha)	2.0	1.9	0.8	1.4	2.0	1.2
	8. Maize production, 1990-92 (000 t)	604	1,229	136	569	14,630	241
	9. Growth rate of maize area, 1973-82 (%/yr)	2.9	2.6	-1.4	0.3	-1.1	-2.3
	10. Growth rate of maize area, 1983-92 (%/yr)	3.0	0.6	-3.5	3.3	-0.2	2.6
	11. Growth rate of maize yield, 1973-82 (%/yr)	0.1	0.1	-0.2	1.6	5.9	1.8
	12. Growth rate of maize yield, 1983-92 (%/yr)	0.5	2.0	-1.6	-0 6	1.3	1.2
	13. Growth rate of maize production, 1973-82 (%/yr)	3.1	2.7	-1.6	1.9	4.8	-0.5
	14. Growth rate of maize production, 1983-92 (%/yr)	3.5	2.7	-5.1	2.7	1.1	3.8
	15. Maize area as percentage of total cereal area, 1990-92	67	88	54	82	71	69
	16. Average yield of all cereals, 1990-92 (t/ha)	1.9	1.9	1.0	1.4	2.4	1.5
	17 Growth rate of yield of all cereals, 1983-92 (%/yr)	1.0	1 8	-0.7	-0.4	0.6	-1.7
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	75	126	2	52	2,265	25
	19. Net imports of maize per capita, 1990-92 (kg/yr)	14	13	0	10	25	6
	20. Per capita total maize consumption, 1990-92 (kg/yr)	126	143	21	117	187	67
	21. Growth rate of per capita maize consumption, 1983-92 (%)	1.1	1.0	-7.7	0.6	-2.0	-2.9
	22. Percent maize used for animal feed, 1988-90 (%)	20	22	6	7	15	4
	23. Percent maize used for direct human consumption, 1988-90 (%)	74	72	86	84	68	84
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	35	31	..	19	41	25
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	71	60	..	..	42	17
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	34	12	..	12	29	3
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	71	36	..	..	25	9
	28. Amount of all maize seed planted, 1992 (000 t)	6.2	15.2	..	12.1	197.9	6.8
	29. Amount of commercial maize seed planted, 1992 (000 t)	2.0	2.0	..	1.2	46.7	0.6
	30. Amount of hybrid seed planted, 1992 (000 t)	2.0	1.5		1.0	43 1	0.2
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	86	55	..	60	44	87
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	4.0	3.7	..	2.4	5.8	5.7
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	4.6	5.3	.	4.3	13.7	6.9
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	5.3	5.8	..	5.2	16.3	8.3
	35. Value of all commercial seed used, 1992 (million US$)	1.7	1.8	..	1.1	171.4	0.6
	36. Value of all hybrid seed used, 1992 (million US$)	1.7	1.5	..	1.0	166.4	0.2
Prices	37. Farm price of maize, 1992 (US$/t)	150	175	..	272	240	160
	38. Ratio of farm level nitrogen price to maize price, 1992	4.0	3.9	..	1.6	1 9	2.4
	39. Farm wage in kg of maize per day, 1992	13.8	17.1	..	6.5	26.7	12.5

Mexico, Central America, and the Caribbean (continued)

		Producer	Consumers					Regional Total or Average
		Panama	Costa Rica	Cuba	Dominican Republic	Jamaica	Trinidad and Tobago	
General indicators	1. Estimated population, 1993 (million)	2.5	3.3	10.9	7.6	2.5	1.3	152.0
	2. Estimated growth rate of population, 1991-2000 (%/year)	1.7	2.0		1.6	0.5	0.9	2
	3. Per capita income, 1991 (US$)	2,130	1,850	.	940	1,380	3,670	2,316
	4. Per capita cereal production, 1990-92 (kg/yr)	124	86	46	71	1	13	199
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-1.1	-7.7	-4.7	-4.0	-14.6	11.8	-2.1
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	75	31	77	35	3	1	9,185
	7 Maize yield, 1990-92 (t/ha)	1.3	1.8	1.2	1.4	1.0	3.0	1.9
	8. Maize production, 1990-92 (000 t)	94	57	95	48	3	3	17,735
	9. Growth rate of maize area, 1973-82 (%/yr)	-2.0	-1.7	-2.5	0.3	-7.9	0.0	-0.7
	10. Growth rate of maize area, 1983-92 (%/yr)	-0.5	-11.0	0.0	-1.2	-1.3	0.0	0.0
	11. Growth rate of maize yield, 1973-82 (%/yr)	1.9	3.9	3.1	-5.1	-0.9	-3.3	5.0
	12. Growth rate of maize yield, 1983-92 (%/yr)	2.9	1.6	0.0	-1.3	-3.3	0.0	1.3
	13. Growth rate of maize production, 1973-82 (%/yr)	-0.1	2.3	0.5	-4.9	-8.7	-3.3	4.2
	14. Growth rate of maize production, 1983-92 (%/yr)	2.4	-9.3	0.0	-2.5	-4.7	0.0	1.3
	15. Maize area as percentage of total cereal area, 1990-92	44	36	37	25	100	17	70
	16. Average yield of all cereals, 1990-92 (t/ha)	1.8	3.1	2.3	3.7	1.0	2.8	2.3
	17 Growth rate of yield of all cereals, 1983-92 (%/yr)	2.0	4.0	-2.0	0.3	-8.9	1.2	0.5
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	74	242	303	440	169	96	3,950
	19. Net imports of maize per capita, 1990-92 (kg/yr)	30	78	28	60	69	74	26
	20. Per capita total maize consumption, 1990-92 (kg/yr)	68	97	37	67	71	76	144
	21. Growth rate of per capita maize consumption, 1983-92 (%)	4.4	8.6	-5.9	8.6	-1.0	0.1	-1.3
	22. Percent maize used for animal feed, 1988-90 (%)	44	67	95	87	73	92	22
	23. Percent maize used for direct human consumption, 1988-90 (%)	52	26	0	9	21	3	64
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	30	22	95	.	..	..	39
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	..	20	..	..	..	..	42
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	19	10	57	..	..	.	27
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	.	6	..	..	..	..	26
	28. Amount of all maize seed planted, 1992 (000 t)	2.1	0.8	1.6	..	..		242.7
	29. Amount of commercial maize seed planted, 1992 (000 t)	0.3	0.1	1.5	.	..		54.3
	30. Amount of hybrid seed planted, 1992 (000 t)	0.3	0.1	0.9	..	.	..	49.0
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	36	30	100	..	..	..	..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	4.6	3.2	4.4	..	..	.	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	9.8	5.2	5.6	..	..	..	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	11.0	6.2	..	.	.	..	..
	35 Value of all commercial seed used, 1992 (million US$)	0.8	0.1	1.5	.	..	..	179.0
	36. Value of all hybrid seed used, 1992 (million US$)	0.7	0.1	1.0	..	..	..	172.6
Prices	37. Farm price of maize, 1992 (US$/t)	240	147	204		..	..	..
	38. Ratio of farm level nitrogen price to maize price, 1992	2.7	3.0	1.8		..	..	..
	39. Farm wage in kg of maize per day, 1992	20.8	41.4	34.1	.	..	..	..

		Andean Region, South America	Producers				Regional Total or Average
			Bolivia	Colombia	Ecuador	Peru	Venezuela
General indicators	1.	Estimated population, 1993 (million)	7.7	34.0	11.3	22.9	20.6	97.6
	2.	Estimated growth rate of population, 1991-2000 (%/year)	2.4	1.5	2.1	1.9	1.9	1.8
	3.	Per capita income, 1991 (US$)	650	1,260	1,000	1.070	2,730	1,449
	4.	Per capita cereal production, 1990-92 (kg/yr)	114	119	135	77	99	109
	5.	Growth rate of per capita cereal production, 1983-92 (%/yr)	-0.4	0.8	7.5	-2.8	1.2	0.5
Production of maize and all cereals	6.	Maize area harvested, 1990-92 (000 ha)	256	785	454	312	452	2,262
	7.	Maize yield, 1990-92 (t/ha)	1.6	1.5	1.1	1.9	2.1	1.6
	8.	Maize production, 1990-92 (000 t)	425	1,181	495	604	957	3,664
	9.	Growth rate of maize area, 1973-82 (%/yr)	4.3	1.1	-2.7	-0.7	-4.2	-0.4
	10.	Growth rate of maize area, 1983-92 (%/yr)	-2.2	4.2	8.9	-2.5	2.7	2.5
	11.	Growth rate of maize yield, 1973-82 (%/yr)	1.9	0.9	3.7	-0.1	4.0	1.8
	12.	Growth rate of maize yield, 1983-92 (%/yr)	1.4	0.5	-1.9	0.9	3.1	0.6
	13.	Growth rate of maize production, 1973-82 (%/yr)	6.2	2.1	1.0	-0.8	-0.2	1.4
	14.	Growth rate of maize production, 1983-92 (%/yr)	-0.8	4.7	7.1	-1.6	5.8	3.1
	15.	Maize area as percentage of total cereal area, 1990-92	43	49	55	45	56	49
	16.	Average yield of all cereals, 1990-92 (t/ha)	1.4	2.5	1.8	2.5	2.4	2.2
	17.	Growth rate of yield of all cereals, 1983-92 (%/yr)	2.2	-0.3	1.0	1.1	3.0	0.7
Trade and utilization	18.	Net imports of maize , 1990-92 (000 t)	-3	194	5	543	577	1,346
	19.	Net imports of maize per capita, 1990-92 (kg/yr)	0	6	0	25	28	14
	20.	Per capita total maize consumption, 1990-92 (kg/yr)	56	41	46	52	76	52
	21.	Growth rate of per capita maize consumption, 1983-92 (%)	-3.6	4.5	4.1	0.3	-5.0	-0.5
	22.	Percent maize used for animal feed, 1988-90 (%)	33	10	52	71	1	32
	23.	Percent maize used for direct human consumption, 1988-90 (%)	60	86	41	20	90	61
Maize seed use and value	24.	Area planted to improved maize as a percentage of total maize area, 1992 (%)	36	31	40	40	100	49
	25.	Area planted to improved maize as a percentage of total maize area, 1985 (%)	..	15	32	50	43	29
	26.	Area planted to hybrids as a percentage of total maize area, 1992 (%)	10	9	10	11	95	27
	27.	Area planted to hybrids as a percentage of total maize area, 1985 (%)	..	13	3	43	30	20
	28.	Amount of all maize seed planted, 1992 (000 t)	6.0	19.5	12.4	5.2	8.9	52.1
	29.	Amount of commercial maize seed planted, 1992 (000 t)	1.2	2.0	1.3	0.8	8.8	14.2
	30.	Amount of hybrid seed planted, 1992 (000 t)	0.6	1.2	0.8	0.6	8.3	11.5
	31.	Percentage of hybrid maize seed that is of public origin, 1992 (%)	3	7	100	39	69	..
	32.	Ratio of the price of commercial OPV seed to the price of grain, 1992	3.6	6.5	4.6	6.7	6.9	..
	33.	Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	8.3	10.4	13.6	10.6	7.8	..
	34.	Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	10.8	11.3	..	14.7	10.0	..
	35.	Value of all commercial seed used, 1992 (million US$)	1.1	2.7	1.9	1.6	8.2	15.4
	36.	Value of all hybrid seed used, 1992 (million US$)	0.8	1.9	1.5	1.2	7.9	13.4
Prices	37.	Farm price of maize, 1992 (US$/t)	110	142	149	170	100	..
	38.	Ratio of farm level nitrogen price to maize price, 1992	10.3	3.1	4.1	7.9	1.9	..
	39.	Farm wage in kg of maize per day, 1992	30.9	17.4	29.5	14.3	38.9	..

		Southern Cone, South America	Producers					Regional Total or Average
			Argentina	Brazil	Chile	Paraguay	Uruguay	
General indicators	1.	Estimated population, 1993 (million)	33.5	156.6	13.8	4.6	3.1	211.5
	2.	Estimated growth rate of population, 1991-2000 (%/year)	1.0	1.4	1.3	2.6	0.6	1.3
	3.	Per capita income, 1991 (US$)	2,790	2,940	2.160	1,270	2,840	2,828
	4.	Per capita cereal production, 1990-92 (kg/yr)	668	246	218	233	393	313
	5.	Growth rate of per capita cereal production, 1983-92 (%/yr)	-6.1	0.7	4.5	-3.2	2.2	-2.0
Production of maize and all cereals	6.	Maize area harvested, 1990-92 (000 ha)	1,970	12,644	103	343	57	15,118
	7.	Maize yield, 1990-92 (t/ha)	3.9	2.0	8.3	1.9	1.8	2.3
	8.	Maize production, 1990-92 (000 t)	7,838	25,235	857	669	106	34,705
	9.	Growth rate of maize area, 1973-82 (%/yr)	-1.3	1.8	3.4	7.3	-7.4	1.1
	10.	Growth rate of maize area, 1983-92 (%/yr)	-6.7	1.6	-2.4	-4.3	-7.0	0.0
	11.	Growth rate of maize yield, 1973-82 (%/yr)	2.7	2.0	1.7	2.0	-0.7	1.9
	12.	Growth rate of maize yield, 1983-92 (%/yr)	2.5	1.9	6.8	1.7	5.3	1.4
	13.	Growth rate of maize production, 1973-82 (%/yr)	1.3	3.8	5.2	9.3	-8.0	3.0
	14.	Growth rate of maize production, 1983-92 (%/yr)	-4.2	3.5	4.5	-2.6	-1.7	1.5
	15.	Maize area as percentage of total cereal area, 1990-92	24	64	14	59	12	51
	16.	Average yield of all cereals, 1990-92 (t/ha)	2.6	1.9	4.0	1.8	2.5	2.2
	17.	Growth rate of yield of all cereals, 1983-92 (%/yr)	1.0	2.2	6.0	1.4	4.0	1.4
Trade and utilization	18.	Net imports of maize , 1990-92 (000 t)	-4,328	653	242	-85	44	-3,474
	19.	Net imports of maize per capita, 1990-92 (kg/yr)	-132	4	18	-20	14	-17
	20.	Per capita total maize consumption, 1990-92 (kg/yr)	107	169	82	134	48	151
	21.	Growth rate of per capita maize consumption, 1983-92 (%)	-1.4	1.6	4.7	-6.6	2.9	1.3
	22.	Percent maize used for animal feed, 1988-90 (%)	82	76	92	71	28	77
	23.	Percent maize used for direct human consumption, 1988-90 (%)	5	13	5	17	55	12
Maize seed use and value	24.	Area planted to improved maize as a percentage of total maize area, 1992 (%)	93	57	90	32	90	62
	25.	Area planted to improved maize as a percentage of total maize area, 1985 (%)	100	70	81	..	..	76
	26.	Area planted to hybrids as a percentage of total maize area, 1992 (%)	85	44	85	19	50	50
	27.	Area planted to hybrids as a percentage of total maize area, 1985 (%)	100	63	68	..	..	70
	28.	Amount of all maize seed planted, 1992 (000 t)	47.2	303.6	2.8	6.4	0.9	361.0
	29.	Amount of commercial maize seed planted, 1992 (000 t)	43.2	121.1	2.4	1.2	0.8	168.6
	30.	Amount of hybrid seed planted, 1992 (000 t)	39.5	108.3	2.3	1.0	0.5	151.5
	31.	Percentage of hybrid maize seed that is of public origin, 1992 (%)	40	15	35	24	20	..
	32.	Ratio of the price of commercial OPV seed to the price of grain, 1992	13.9	5.9	17.0	6.4	6.0	..
	33.	Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	26.4	8.0	26.4	12.2	16.0	..
	34.	Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	26.9	10.0	27.5	12.2	18.0	..
	35.	Value of all commercial seed used, 1992 (million US$)	85.0	143.8	11.3	1.5	1.0	242.6
	36.	Value of all hybrid seed used, 1992 (million US$)	81.3	135.3	11.1	1.3	0.8	229.9
Prices	37.	Farm price of maize, 1992 (US$/t)	72	112	153	111	100	..
	38.	Ratio of farm level nitrogen price to maize price, 1992	6.3	4.0	3.8	7.2	4.4	..
	39.	Farm wage in kg of maize per day, 1992	173.6	46.4	39.2	55.0	80.0	..

Eastern Europe and the Former Soviet Union

		Producers				
		Albania	Bulgaria	Czechoslovakia	Hungary	Romania
General indicators	1. Estimated population, 1993 (million)	3.4	9.0	..	10.3	23.4
	2. Estimated growth rate of population, 1991-2000 (%/year)	..	-0.2	..	-0.4	0.2
	3. Per capita income, 1991 (US$)	..	1,840	2,470	2,720	1,390
	4. Per capita cereal production, 1990-92 (kg/yr)	213	887	739	1250	702
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-7.9	0.5	-0.2	-1.4	-2.9
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	54	528	160	1,116	2,793
	7. Maize yield, 1990-92 (t/ha)	3.9	3.9	4.0	5.1	3.0
	8. Maize production, 1990-92 (000 t)	209	2,099	650	5,718	8,045
	9. Growth rate of maize area, 1973-82 (%/yr)	-0.8	-0.3	2.0	-2.6	-0.3
	10. Growth rate of maize area, 1983-92 (%/yr)	-6.4	0.1	-1.6	0.0	-0.9
	11. Growth rate of maize yield, 1973-82 (%/yr)	5.3	2.9	1.8	5.2	3.1
	12. Growth rate of maize yield, 1983-92 (%/yr)	0.2	-2.9	-2.3	-2.2	-3.7
	13. Growth rate of maize production, 1973-82 (%/yr)	4.4	2.6	3.8	2.6	2.8
	14. Growth rate of maize production, 1983-92 (%/yr)	-6.2	-2.8	-3.9	-2.3	-4.6
	15. Maize area as percentage of total cereal area, 1990-92	20	25	7	41	48
	16. Average yield of all cereals, 1990-92 (t/ha)	2.6	3.8	4.8	4.8	2.8
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	-2.0	0.3	0.5	-0.8	-1.7
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	10	124	81	-800	511
	19. Net imports of maize per capita, 1990-92 (kg/yr)	3	14	5	-77	22
	20. Per capita total maize consumption, 1990-92 (kg/yr)	66	247	47	475	369
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-7.5	-2.7	-7.3	-4.5	-3.8
	22. Percent maize used for animal feed, 1988-90 (%)	34	84	89	89	74
	23. Percent maize used for direct human consumption, 1988-90 (%)	58	0	0	0	13
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	..	100	100	..	..
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	..	100	..	..	..
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	..	100	100	..	..
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	..	100	..	..	..
	28. Amount of all maize seed planted, 1992 (000 t)	..	19.0	12.0	..	..
	29. Amount of commercial maize seed planted, 1992 (000 t)	..	19.0	12.0	..	..
	30. Amount of hybrid seed planted, 1992 (000 t)	..	19.0	12.0	..	..
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	..	100	79	..	..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	..	..	..	..	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..	16.1	13.2	..	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..	21.4	14.6	..	..
	35. Value of all commercial seed used, 1992 (million US$)	..	38.0	17.3	..	..
	36. Value of all hybrid seed used, 1992 (million US$)	..	38.0	17.3	..	..
Prices	37. Farm price of maize, 1992 (US$/t)	..	..	..	..	..
	38. Ratio of farm level nitrogen price to maize price, 1992	..	2.7	6.0	..	..
	39. Farm wage in kg of maize per day, 1992	..	..	35.7	..	..

Eastern Europe and the Former Soviet Union (continued)

		Producers		Consumer	Regional Total or Average
		Former Soviet Union[1]	Former Yugoslavia[1]	Poland	
General indicators	1. Estimated population, 1993 (million)	294.6	24.0	38.6	418.5
	2. Estimated growth rate of population, 1991-2000 (%/year)	0.0		0.3	0.0
	3. Per capita income, 1991 (US$)	3,220	..	1,790	2,896
	4. Per capita cereal production, 1990-92 (kg/yr)	631	624	660	659
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	0.3	-3.2	0.1	-0.3
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	2,936	2,198	62	9,847
	7. Maize yield, 1990-92 (t/ha)	3.1	3.8	4.5	3.5
	8. Maize production, 1990-92 (000 t)	9,002	8,435	279	34,438
	9. Growth rate of maize area, 1973-82 (%/yr)	0.6	-0.6	12.1	-0.3
	10. Growth rate of maize area, 1983-92 (%/yr)	-4.0	-0.8	19.3	-1.7
	11. Growth rate of maize yield, 1973-82 (%/yr)	0.7	3.1	0.3	2.5
	12. Growth rate of maize yield, 1983-92 (%/yr)	-1.3	-3.2	0.6	-2.3
	13. Growth rate of maize production, 1973-82 (%/yr)	1.3	2.5	12.5	2.2
	14. Growth rate of maize production, 1983-92 (%/yr)	-5.3	-4.0	19.9	-4.0
	15. Maize area as percentage of total cereal area, 1990-92	3	56	1	8
	16. Average yield of all cereals, 1990-92 (t/ha)	1.8	3.7	3.0	2.1
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	2.4	-1.4	0.0	1.5
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	11,252	256	366	11,799
	19. Net imports of maize per capita, 1990-92 (kg/yr)	39	11	10	28
	20. Per capita total maize consumption, 1990-92 (kg/yr)	70	363	17	111
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-2.5	-2.8	5.3	-3.2
	22. Percent maize used for animal feed, 1988-90 (%)	75	83	73	79
	23. Percent maize used for direct human consumption, 1988-90 (%)	<1	6	0	4
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)				100 *
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)		..	..	95
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	..		..	100
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	..		.	95
	28. Amount of all maize seed planted, 1992 (000 t)		..		31.0
	29. Amount of commercial maize seed planted, 1992 (000 t)	..	.	..	31.0
	30. Amount of hybrid seed planted, 1992 (000 t)	..		..	31.0
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	..	..	..	..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	..		..	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..	..	.	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..		..	..
	35. Value of all commercial seed used, 1992 (million US$)	..		..	55.3
	36. Value of all hybrid seed used, 1992 (million US$)	.		..	55.3
Prices	37. Farm price of maize, 1992 (US$/t)	..		..	..
	38. Ratio of farm level nitrogen price to maize price, 1992	..		..	..
	39. Farm wage in kg of maize per day, 1992	..		.	..

[1] Data cover the some areas previously designated as the USSR and Yugoslavia.

* Maize seed use and value variables are for Bulgaria and Slovak Republic only.

Developed Market Economies

		Producers				
		Austria	Canada	France	Germany	Greece
General indicators	1. Estimated population, 1993 (million)	7.9	27.7	57.5	80.7	10.2
	2. Estimated growth rate of population, 1991-2000 (%/year)	0.4	0.8	0.4	0.0	0.1
	3. Per capita income, 1991 (US$)	20,140	20,440	20,380	23,650	6,340
	4. Per capita cereal production, 1990-92 (kg/yr)	627	1976	1034	467	537
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-1.7	0.1	1.4	0.1	1.4
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	185	972	1,728	263	217
	7. Maize yield, 1990-92 (t/ha)	8.2	6.5	7.0	7.11	9.9
	8. Maize production, 1990-92 (000 t)	1,514	6,337	12,234	1,876	2,136
	9. Growth rate of maize area, 1973-82 (%/yr)	3.9	8.9	-1.2	3.8	2.6
	10. Growth rate of maize area, 1983-92 (%/yr)	-1.9	-2.3	0.1	5.6	0.3
	11. Growth rate of maize yield, 1973-82 (%/yr)	2.2	1.7	2.9	3.0	11.1
	12. Growth rate of maize yield, 1983-92 (%/yr)	1.1	1.2	2.3	2.9	1.1
	13. Growth rate of maize production, 1973-82 (%/yr)	6.1	10.6	1.6	6.7	13.7
	14. Growth rate of maize production, 1983-92 (%/yr)	-0.8	-1.1	2.1	8.5	1.4
	15. Maize area as percentage of total cereal area, 1990-92	21	5	19	4	15
	16. Average yield of all cereals, 1990-92 (t/ha)	5.4	2.6	6.4	5.6	3.7
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	1.1	1.6	2.4	2.1	2.4
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	-106	141	-6,134	1,201	-215
	19. Net imports of maize per capita, 1990-92 (kg/yr)	-14	5	-108	15	-21
	20. Per capita total maize consumption, 1990-92 (kg/yr)	181	241	108	32	191
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-2.0	-1.6	-2.2	-2.3	-1.2
	22. Percent maize used for animal feed, 1988-90 (%)	89	79	79	65	89
	23. Percent maize used for direct human consumption, 1988-90 (%)	1	1	11	14	0
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)		100	100	100	100
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)		100	100	100	100
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)		100	100	100	100
	27 Area planted to hybrids as a percentage of total maize area, 1985 (%)	.	100	100	100	100
	28. Amount of all maize seed planted, 1992 (000 t)	.	13.5	91.5	41.5	3.4
	29. Amount of commercial maize seed planted, 1992 (000 t)	..	13.5	91.5	41.5	3.4
	30. Amount of hybrid seed planted, 1992 (000 t)	..	13.5	91.5	41.5	3.4
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)		5	0	0	6
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	..	..	..	..	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..	..	..	.	18.8
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992		35.0	42.0	40.3	25.0
	35. Value of all commercial seed used, 1992 (million US$)		52.0	533.4	244.0	16.1
	36. Value of all hybrid seed used, 1992 (million US$)	.	52.0	533.4	244.0	16.1
Prices	37 Farm price of maize, 1992 (US$/t)		110	167	144	192
	38. Ratio of farm level nitrogen price to maize price, 1992		4.5	2.6	4.0	2.3
	39. Farm wage in kg of maize per day, 1992	.	500.0	309.7	290.3	93.8

Developed Market Economies
(contniued)

			Producers			
		Italy	South Africa*	Spain	Switzerland	U.S.A.
General indicators	1. Estimated population, 1993 (million)	57.9	40.8	39.1	6.9	257.5
	2. Estimated growth rate of population, 1991-2000 (%/year)	0.1	2.2	0.1	0.7	0.9
	3. Per capita income, 1991 (US$)	18,520	2,560	12,450	33,610	22,240
	4. Per capita cereal production, 1990-92 (kg/yr)	325	247	446	188	1253
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-0.2	-2.1	-0.3	3.1	0.8
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	824	3,318	456	25	28,050
	7. Maize yield, 1990-92 (t/ha)	7.8	2.1	6.5	8.6	7.5
	8. Maize production, 1990-92 (000 t)	6,424	6,725	2,961	217	210,730
	9. Growth rate of maize area, 1973-82 (%/yr)	1.3	-1.6	-1.9	-2.4	1.7
	10. Growth rate of maize area, 1983-92 (%/yr)	-1.9	-2.5	0.9	3.7	1.2
	11. Growth rate of maize yield, 1973-82 (%/yr)	2.8	7.4	4.4	3.0	3.6
	12. Growth rate of maize yield, 1983-92 (%/yr)	1.8	4.0	1.7	2.8	2.5
	13. Growth rate of maize production, 1973-82 (%/yr)	4.1	5.8	2.5	0.6	5.2
	14. Growth rate of maize production, 1983-92 (%/yr)	-0.1	1.4	2.7	6.5	3.6
	15. Maize area as percentage of total cereal area, 1990-92	19	60	6	12	43
	16. Average yield of all cereals, 1990-92 (t/ha)	4.3	1.6	2.3	6.1	4.9
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	2.0	2.7	-0.1	1.7	2.2
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	932	-317	1,565	60	-46,435
	19. Net imports of maize per capita, 1990-92 (kg/yr)	16	-910	40	9	-185
	20. Per capita total maize consumption, 1990-92 (kg/yr)	127	178	115	41	652
	21. Growth rate of per capita maize consumption, 1983-92 (%)	-0.9	-1.8	-4.4	-4.9	4.3
	22. Percent maize used for animal feed, 1988-90 (%)	88	39	85	82	77
	23. Percent maize used for direct human consumption, 1988-90 (%)	3	53	1	3	2
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	100	100	85	.	100
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	100	97	100		100
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	99	94	85	..	100
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	100	95	100	.	100
	28. Amount of all maize seed planted, 1992 (000 t)	15.5	37.5	9.4	..	525.5
	29. Amount of commercial maize seed planted, 1992 (000 t)	15.5	37.5	8.0		525.5
	30. Amount of hybrid seed planted, 1992 (000 t)	15.3	35.0	8.0		525.5
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	1	0	6		5
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	11.0	..	5.8	..	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	29.0		26.0		..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	29.7	13.2	26.9	.	35.2
	35. Value of all commercial seed used, 1992 (million US$)	91.7	58.5	39.9	..	2,054.7
	36. Value of all hybrid seed used, 1992 (million US$)	91.4	56.7	39.9	..	2,054.7
Prices	37 Farm price of maize, 1992 (US$/t)	176	123	186		110
	38. Ratio of farm level nitrogen price to maize price, 1992	2.2	5.0	3.1	..	4.5
	39. Farm wage in kg of maize per day, 1992	355.2	48.0	153.8	.	500.0

* South Africa experienced a severe drought in 1992 which substantially affected maize yields. Please see Notes on the Variables.

Developed Market Economies
(continued)

		Consumers					Regional Total or Average
		Belgium/ Luxembourg	Japan	Netherlands	Portugal	United Kingdom	
General indicators	1. Estimated population, 1993 (million)	10.4	124.9	15.3	9.8	58.1	847.8
	2. Estimated growth rate of population, 1991-2000 (%/year)	0.2	0.3	0.8	0.0	0.2	0.6
	3. Per capita income, 1991 (US$)	18,950	26,930	18,780	5,930	16,550	20,253
	4. Per capita cereal production, 1990-92 (kg/yr)	214	113	87	143	389	720
	5. Growth rate of per capita cereal production, 1983-92 (%/yr)	0.0	-1.7	-0.4	1.2	-0.9	0.3
Production of maize and all cereals	6. Maize area harvested, 1990-92 (000 ha)	9	0	0	209	0	36,327
	7. Maize yield, 1990-92 (t/ha)	8.2	..	..	3.1	..	6.9
	8. Maize production, 1990-92 (000 t)	71	1	4	645	0	252,254
	9. Growth rate of maize area, 1973-82 (%/yr)	3.8	..	..	-3.2	..	1.2
	10. Growth rate of maize area, 1983-92 (%/yr)	4.2	..	..	-3.3	..	0.5
	11. Growth rate of maize yield, 1973-82 (%/yr)	2.1	..	..	1.6	..	3.9
	12. Growth rate of maize yield, 1983-92 (%/yr)	1.7	..	..	6.5	..	2.7
	13. Growth rate of maize production, 1973-82 (%/yr)	6.0	..	..	-1.6	..	5.1
	14. Growth rate of maize production, 1983-92 (%/yr)	6.0	..	..	3.3	..	3.2
	15. Maize area as percentage of total cereal area, 1990-92	2	0	0	26	0	25
	16. Average yield of all cereals, 1990-92 (t/ha)	6.3	5.7	7.2	1.9	6.3	4.1
	17. Growth rate of yield of all cereals, 1983-92 (%/yr)	1.8	0.0	1.0	4.5	1.1	2.1
Trade and utilization	18. Net imports of maize , 1990-92 (000 t)	1,020	16,345	1,883	783	1,598	-43,267
	19. Net imports of maize per capita, 1990-92 (kg/yr)	99	132	125	76	28	-51
	20. Per capita total maize consumption, 1990-92 (kg/yr)	105	132	125	139	28	248
	21. Growth rate of per capita maize consumption, 1983-92 (%)	1.2	1.3	-2.0	-8.2	-0.4	2.6
	22. Percent maize used for animal feed, 1988-90 (%)	55	77	54	89	15	72
	23. Percent maize used for direct human consumption, 1988-90 (%)	2	18	3	7	11	14
Maize seed use and value	24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	..	..	100	..	..	100
	25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	..	..	..	..	..	99
	26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	..	..	100	..	..	99
	27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	..	..	..	..	..	99
	28. Amount of all maize seed planted, 1992 (000 t)	..	..	9.0	..	..	746.8
	29. Amount of commercial maize seed planted, 1992 (000 t)	..	..	9.0	..	..	745.4
	30. Amount of hybrid seed planted, 1992 (000 t)	..	..	9.0	..	..	742.7
	31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	..	..	0	..	..	..
	32. Ratio of the price of commercial OPV seed to the price of grain, 1992	..	..	..	..	..	..
	33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..	..	..	..	..	..
	34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..	..	34.7	..	..	..
	35. Value of all commercial seed used, 1992 (million US$)	..	..	45.0	..	..	3,135.0
	36. Value of all hybrid seed used, 1992 (million US$)	..	..	45.0	..	..	3,133.2
Prices	37 Farm price of maize, 1992 (US$/t)	..	..	144	..	..	..
	38. Ratio of farm level nitrogen price to maize price, 1992	..	..	38.5	..	..	..
	39. Farm wage in kg of maize per day, 1992	..	..	290.3	..	..	..

Regional Aggregates	Less Developed Countries	Developed Market Economies	Eastern Europe and Former Soviet Union*	World
1. Estimated population, 1993 (million)	4,295.5	847.8	418.5	5479.0
2. Estimated growth rate of population, 1991-2000 (%/year)	1.8	0.6	0.0	1.5
3. Per capita income, 1991 (US$)	829	20,253	2,896	4,176
4. Per capita cereal production, 1990-92 (kg/yr)	254	720	659	358
5. Growth rate of per capita cereal production, 1983-92 (%/yr)	-0.1	0.3	-0.3	-0.3
6. Maize area harvested, 1990-92 (000 ha)	83,630	36,327	9,847	129,804
7. Maize yield, 1990-92 (t/ha)	2.5	6.9	3.5	3.8
8. Maize production, 1990-92 (000 t)	213,062	252,254	34,438	498,857
9. Growth rate of maize area, 1973-82 (%/yr)	0.6	1.2	-0.3	0.7
10. Growth rate of maize area, 1983-92 (%/yr)	1.1	0.5	-1.7	0.6
11. Growth rate of maize yield, 1973-82 (%/yr)	3.1	3.9	2.5	3.6
12. Growth rate of maize yield, 1983-92 (%/yr)	2.1	2.7	-2.3	1.8
13. Growth rate of maize production, 1973-82 (%/yr)	3.7	5.1	2.2	4.3
14. Growth rate of maize production, 1983-92 (%/yr)	3.2	3.2	-4.0	2.5
15. Maize area as percentage of total cereal area, 1990-92	20	25	8	19
16. Average yield of all cereals, 1990-92 (t/ha)	2.5	4.1	2.1	2.8
17. Growth rate of yield of all cereals, 1983-92 (%/yr)	1.6	2.1	1.5	1.6
18. Net imports of maize , 1990-92 (000 t)	14,838	-43,267	11,799	..
19. Net imports of maize per capita, 1990-92 (kg/yr)	4	-51	28	..
20. Per capita total maize consumption, 1990-92 (kg/yr)	55	248	111	94
21. Growth rate of per capita maize consumption, 1983-92 (%)	1.3	2.6	-3.2	0.7
22. Percent maize used for animal feed, 1988-90 (%)	48	72	79	64
23. Percent maize used for direct human consumption, 1988-90 (%)	40	14	4	21
24. Area planted to improved maize as a percentage of total maize area, 1992 (%)	58	100	100	72
25. Area planted to improved maize as a percentage of total maize area, 1985 (%)	51	99	95	71
26. Area planted to hybrids as a percentage of total maize area, 1992 (%)	44	99	100	61
27. Area planted to hybrids as a percentage of total maize area, 1985 (%)	38	99	95	63
28. Amount of all maize seed planted, 1992 (000 t)	2,317.6	746.8	31.0	3,095.4
29. Amount of commercial maize seed planted, 1992 (000 t)	1,109.0	745.4	31.0	1,885.4
30. Amount of hybrid seed planted, 1992 (000 t)	995.6	742.7	31.0	1,769.3
31. Percentage of hybrid maize seed that is of public origin, 1992 (%)	..	..	..	..
32. Ratio of the price of commercial OPV seed to the price of grain, 1992		..	.	..
33. Ratio of the price of popular public origin hybrid seed to the price of grain, 1992	..	..	..	..
34. Ratio of the price of popular proprietary origin hybrid seed to the price of grain, 1992	..	..	..	..
35. Value of all commercial seed used, 1992 (million US$)	833.9	3,135.0	55.3	4,024.2
36. Value of all hybrid seed used, 1992 (million US$)	772.5	3,133.2	55.3	3,961.0
37. Farm price of maize, 1992 (US$/t)	..	..	..	..
38. Ratio of farm level nitrogen price to maize price, 1992	..	..	..	..
39. Farm wage in kg of maize per day, 1992	..	..	..	..

* Data for the Former Soviet Union cover the same area previously designated as the USSR.

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Annex 1: Regions of the World and Countries Responding to the Maize Seed Industry Survey

Developing Countries

Eastern and Southern Africa
Angola
Botswana
Burundi*
Comoros
Djibouti
Ethiopia*
Kenya*
Lesotho*
Madagascar
Malawi*
Mauritius
Mozambique*
Namibia
Rwanda*
Seychelles
Somalia
Sudan
Swaziland
Tanzania*
Uganda*
Zambia*
Zimbabwe*

Western and Central Africa
Benin*
Burkina Faso*
Cameroon*
Cape Verde
Central Africa Republic
Chad
Congo
Côte d'Ivoire*
Equatorial Guinea
Gabon
Gambia
Ghana*
Guinea
Guinea-Bissau
Liberia
Mali*
Mauritania
Niger
Nigeria*
Reunion
São Tomé
Senegal*
Sierra Leone
St. Helena
Togo*
Zaire

North Africa
Algeria
Egypt*
Libya
Morocco*
Tunisia

West Asia
Afghanistan
Bahrain
Cyprus
Iran
Iraq
Jordan
Kuwait
Lebanon
Oman
Qatar
Saudi Arabia
Syria*
Turkey*
United Arab Emirates
Yemen Arab Republic

South Asia
Bangladesh
Bhutan
India*
Maldives
Myanmar
Nepal*
Pakistan*
Sri Lanka

Southeast Asia and the Pacific
American Samoa
Brunei
Cook Islands
East Timor
Fiji
French Polynesia
Guam
Hong Kong
Indonesia*
Kampuchea Republic
Kiribati
Laos
Macau
Malaysia
Nauru
New Caledonia
Niue
Norfolk Island
Pacific Islands
Papua New Guinea
Philippines*
Samoa
Singapore
Solomon Islands
Thailand*
Tokelau
Tonga
Tuvalu
Vanuatu
Vietnam*
Wallis and Futana Island

East Asia
China*
Korea D.P.R.
Korea, Republic
Mongolia
Taiwan*

Mexico, Central America, and the Caribbean
Antigua
Bahamas
Barbados
Belize
Bermuda
Cayman Islands
Costa Rica*
Cuba*
Dominica
Dominican Republic
El Salvador*
Grenanda
Guadeloupe
Guatemala*
Haiti
Honduras*
Jamaica
Martinique
Mexico*
Montserrat
Netherlands Antiles
Nicaragua*
Panama*
St. Christopher and Nevis
St. Lucia
St. Pierre and Miquelon
St. Vincent and the Grenadines
Trinidad and Tobago
U.K. Virgin Islands
U.S. Virgin Islands

Andean Region, South America
Bolivia*
Colombia*
Ecuador*
French Guiana
Guyana
Peru*
Surinam
Venezuela*

Southern Cone, South America
Argentina*
Brazil*
Chile*
Paraguay*
Uruguay*
Falkland Islands

Eastern Europe and Former Soviet Union
Albania
Bulgaria*
Czech Republic
Hungary
Poland
Romania
Slovak Republic*
Former Soviet Union
Former Yugoslavia

Develop Market Economies
Australia
Austria
Belgium-Luxembourg
Canada*
Denmark
Faeroe Island
Finland
France*
Germany*
Greece*
Greenland
Iceland
Ireland
Israel
Italy*
Japan
Malta
Netherlands*
New Zealand
Norway
Portugal
South Africa*
Spain*
Sweden
Switzerland
United Kingdom
United States*

* Countries included in the 1993 Maize Seed Industry Survey.

ISSN: 0257-8743
ISBN: 968-6923-28-4

Centro Internacional de Mejoramiento de Maíz y Trigo
International Maize and Wheat Improvement Center
Lisboa 27, Apartado Postal 6-641, 06600 México, D.F., México