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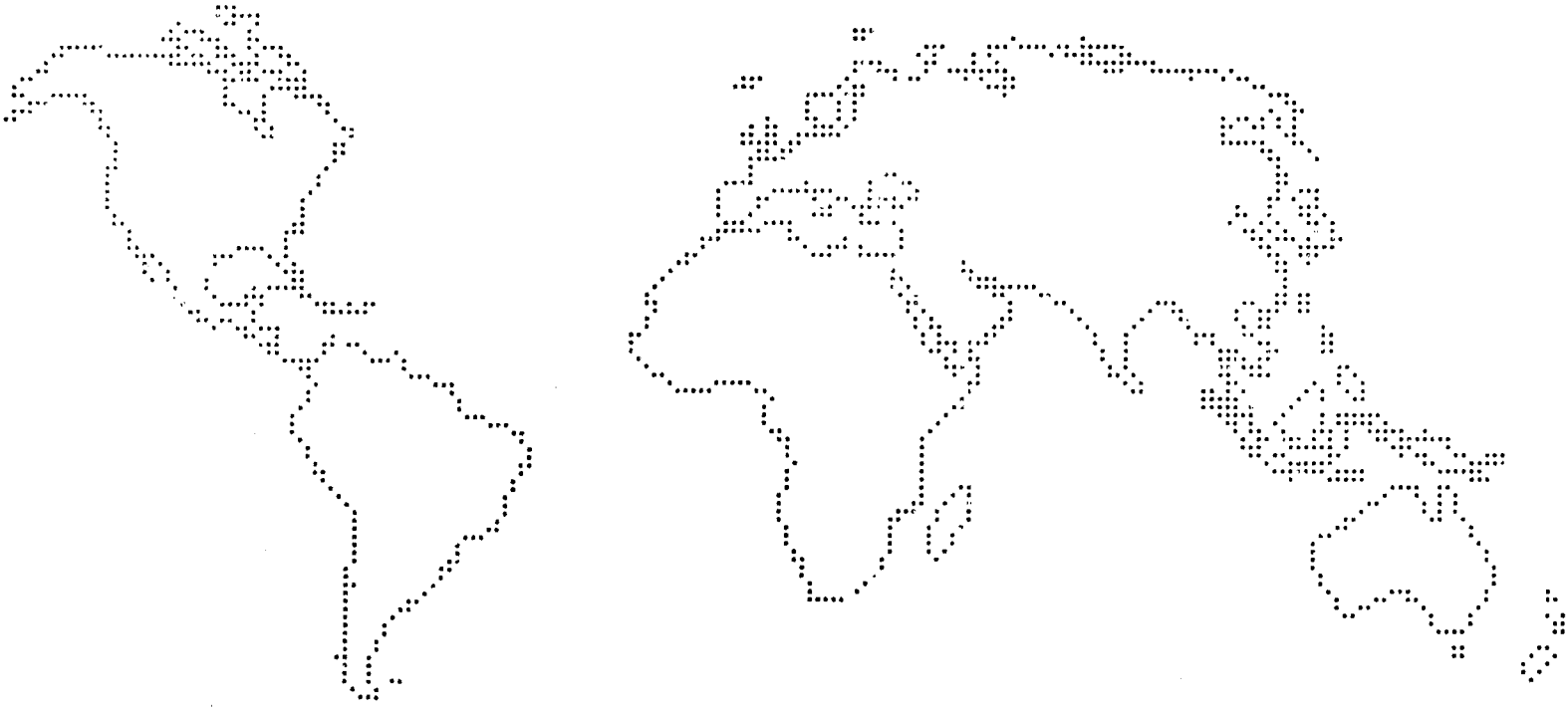

The Economics of Commercial Maize Seed Production in Developing Countries

The International Maize and Wheat Improvement Center (CIMMYT) is an internationally funded, nonprofit scientific research and training organization. Headquartered in Mexico, the Center is engaged in a worldwide research program for maize, wheat, and triticale, with emphasis on food production in developing countries. It is one of 13 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 40 donor countries, international and regional organizations, and private foundations.

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Foreword

Over the past two decades a wealth of improved maize germplasm has been developed for the most important maize-growing environments in the Third World, but even though seed derived from that germplasm has the potential for sizeably increasing productivity in maize, most maize farmers in developing countries are not growing it. In many countries adoption of improved seed has been limited by a lack of inputs and incentives or ineffective research and extension, while in other countries, or regions within them, uptake of improved maize has been slowed by economic aspects of seed use, particularly in the poorer and lower yielding environments. Ineffective seed production and marketing have also proved to be major bottlenecks to improved productivity in maize.

Development of seed industries is an important issue for many governments and agricultural research programs in the Third World. It is also of major concern to CIMMYT, since we are engaged in the development of improved maize germplasm and have an obvious interest in improving its ultimate dissemination among farmers. The study reported in this publication was conducted to pinpoint problems and analyze some economic issues in seed industry development.

Numerous types of commercial seed are available, ranging in productivity and cost from farmers' own seed to hybrids. Use of improved varieties and especially hybrids will expand in developing countries with growth in seed industries. Those changes are an inevitable consequence of overall economic and agricultural development in Third World countries and of corresponding changes in agricultural practices. The process of change in seed production will require well-informed decision making aimed at targeting seed types for particular regions and groups of farmers. In some cases introduction of hybrids will be advisable, whereas in others it will be more appropriate for farmers and seed producers to concentrate on improved open-pollinated varieties. A valuable contribution of this study is to provide information on the circumstances under which particular types of maize seed are likely to be economically attractive to farmers.

CIMMYT staff at headquarters and in our regional programs will become more deeply involved in seed issues during the coming years. Already we have one full-time seed specialist based in Guatemala and are currently seeking donors to fund regional positions elsewhere. Countries in regions where we cannot place a seed specialist will receive assistance from a maize staff member based at headquarters who will devote part of his time to this task. Obviously, the consultation and training we offer will have to cover the complex economic and financial aspects of seed production as well as all of the main technical matters. Toward that end we will seek to cooperate with groups that are experienced in commercial seed production.

Another one of our aims is to encourage persons interested in seed industry development in the Third World to share ideas and plan jointly for training and other cooperative efforts. Our hope is that countries with fledgling seed industries will profit from the experiences of countries with well-functioning seed industries and from organizations such as the International Center of Tropical Agriculture in Colombia (CIAT, which has a special seed unit and offers training in seed production).

This issue of *Maize Facts and Trends* provides valuable information on the economic aspects of commercial maize seed. We hope it will be widely read by individuals whose task is to provide maize seed to farmers in developing countries.

Donald L. Winkelmann
Director General
CIMMYT

Preface

The two previous issues of *CIMMYT World Maize Facts and Trends* have analyzed changes in the production and utilization of maize in developing countries. A task that impinges greatly on both those activities is the subject of this third report, which focuses on the production of commercial maize seed.

The report consists of three main sections. The first examines trends in the utilization of maize seed, in the costs of producing it, and in the prices paid for it. This section also addresses issues that are of much concern to maize researchers and others who wish to encourage the growth of seed industries in the Third World.

Part 2 provides an overview of current trends in global maize production, trade, and prices. This discussion may be of particular interest at a time when, as a result of growing protectionism and falling export prices, policy makers are paying especially close attention to developments in the international grain markets.

Part 3 gives data (in tabular form) on the use of maize seed and the area planted to improved germplasm, along with statistics on maize production, utilization, trade, and prices. Data are given for all developing countries whose annual maize production, utilization, or both have exceeded 100,000 t in recent years. Regional and world totals are provided as well for the 30 statistics included in this section.

The information on which Part 1 is based and some of the data included in Part 3 were provided by a number of persons around the world, who were sent one of two types of questionnaires. Outreach staff of the CIMMYT Maize Program and their colleagues in national maize research programs were asked to supply figures on the amount of maize seed planted, area sown to improved maize, and so on for each of the major maize-producing countries of the world. Maize seed enterprises received a different questionnaire soliciting data on costs, prices, yields, and other variables in the production of maize seed. The methods and assumptions of this study and more detailed analysis will be reported in a working paper being prepared by the CIMMYT Economics Program (Longmire and Stewart).

One fundamental question addressed in this report is the degree to which maize research programs and the seed industry should be geared to hybrid development. The answer will vary from one region to another, depending on the circumstances of farmers, maize research programs, and seed industries. Though most often grown on a large scale in commercial operations, hybrids can be compatible with small-scale maize production if they are suited to the biological, economic, and social conditions of farmers. To help determine when that is the case, we describe the conditions under which different types of maize seed are likely to be appropriate.

We also provide information on the important question of public and private sector involvement in maize seed production and marketing and the related issue of maize seed pricing. Seed industries are likely to founder unless prices remain flexible enough to provide proper incentives for all parties concerned and accurately reflect the economics of the seed situation.

In exploring those and other issues, we did not have the opportunity to cover all countries as thoroughly as we would have liked. We therefore encourage readers to provide further information, especially from countries for which data on maize seed are not reported in section 3 of this publication. Although the data and analysis presented here relate specifically to maize, many of the points made are relevant to other crops as well, especially the cross-pollinated ones for which hybrid seed can be produced economically. We hope this information proves to be a valuable resource for all persons who share our conviction that seed industries have a vital role to play in the agricultural development of Third World countries.

Acknowledgments

This publication was prepared by staff of the CIMMYT Economics Program in conjunction with the Center's Information Services staff. The work was coordinated by Jim Longmire under the direction of Robert Tripp, with significant contributions from Rigoberto Stewart, Dagoberto Flores, Luis Castro, and Beatriz Avalos. Russell Cormier of CIMMYT's Data Processing Services made important contributions in the preparation of data. Early drafts of the manuscript were typed accurately by Claudia De Alba. The report was edited by Nathan Russell of Information Services, with assistance from Tiffin Harris. Typesetting was done by Silvia Bistrain R. and Maricela A. de Ramos. Graphics were designed and prepared (as was the entire publication) by Miguel Mellado E., Jose Manuel Fouilloux, Rafael De la Colina, and Bertha Regalado M.

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A number of people took time to provide information that helped immensely in the preparation of this report. We acknowledge in particular the assistance given by staff of the FAO Basic Statistics Unit. Thanks are due to many others as well (especially our colleagues in CIMMYT outreach programs and many staff in national maize research programs and seed enterprises) for the information and assistance they provided. We hope the report does justice to their work and interest in the economics of maize seed.

Part 1: The Economics of Commercial Maize Seed Production in Developing Countries

The Varied Pattern of Maize Seed Use

A close examination of maize seed use around the world reveals several diverse patterns. Two prominent features are the marked contrasts between regions and the relatively limited spread of improved maize seed in the Third World. Examination of those patterns helps put in perspective the challenge that lies ahead of national maize research programs, seed enterprises, and other groups interested in the development and dissemination of improved maize seed.

A disparity between volume and value—One very conspicuous pattern in seed use is the low value of the relatively large quantity of seed planted in developing countries.

According to the best available estimates, almost 140 million hectares of maize were planted worldwide in 1985-86 (Figure 1). Of this total area, about 60% was planted in developing countries, with those in Asia (including China) containing just over 27%, Latin America slightly more than 20%, and Africa around 12%. Four countries (China, Brazil, India, and Mexico) accounted for more than 50% of the total area planted to maize in the Third World.

During 1985-86 farmers planted some 3.2 million tons of maize seed worldwide, about 1 million in developed and the remainder in developing countries. At prevailing prices and exchange rates, the global value of that seed (including the value we assigned to farmers' own seed) was about US$3.2 billion. The seed planted in developed countries had a total value of over US$2.4 billion (because of the predominance of high-value hybrid seed in North America, western and eastern Europe, the USSR, and South Africa), whereas that sown in the Third World was worth just under US$800 million. Thus, farmers in developing countries planted almost 70% of the world's maize seed on a tonnage basis, but its US dollar value was less than a quarter of the world total.

Essentially the same pattern emerged when we converted the US dollar value of maize seed planted in 1985-86 to its equivalent in tons of maize grain, using the farm prices of maize seed and grain in each country. The total value of the world's seed supply was equivalent to around 23 million tons of maize grain or, on the average, 7.5 times the price of grain. Of that total, three-fourths belonged to developed countries and a little more than 12% to Third World nations, excluding Argentina, Brazil, and China. The USA alone, even though it had only 23% of the global area planted to maize, had 46% of the value of all maize seed in the world on a maize-equivalent basis. The value of maize seed in Africa, on the other hand, which has 12% of the world's maize area, amounted to only 4% of the global value.

Area planted to improved maize—The sizeable gap between the volume of maize seed planted and its value in developing countries is accounted for in large part by a general scarcity of improved seed. In some of those countries, effective maize research and seed distribution have led to extensive adoption of improved maize—open-pollinated varieties (OPVs) and hybrids—but in general the spread of this material has been limited, in some cases extremely so.

Our estimates were provided by maize specialists in many countries, who tried to gauge the area planted to hybrids or to open-pollinated maize derived from commercial varieties released during the past 10 years, including farmers' own seed from such varieties. The purpose of the 10-year limit (a figure suggested by the maize specialists) was to exclude varieties released so long ago that they have undergone considerable intermixing in farmers' fields. Second- and later generation hybrid seed was not counted as improved material either, but as farmers' own seed.

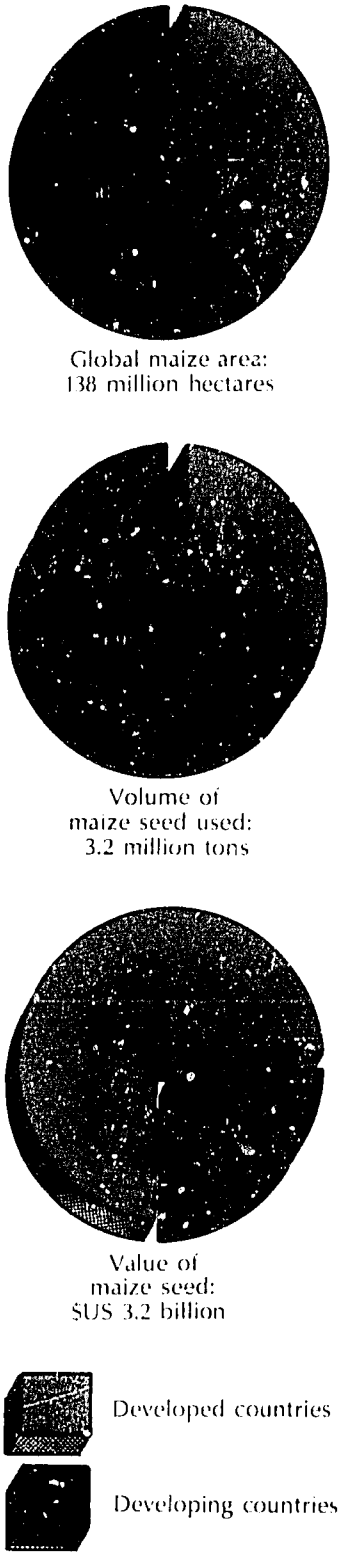

Figure 1. Third World countries' estimated share of the area planted to maize, tons of seed used, and value of seed worldwide.

According to the estimates, about half of the maize planted in the Third World during 1985-86 was improved. There is, of course, much regional variation in the proportion planted to improved maize, as indicated in Figure 2. In Africa, for example, only one-third of the maize sown was improved, compared with almost 60% in Asia and Latin America. The overall percentage is much reduced, however, if we exclude large countries with sizeable areas planted to improved maize, particularly Argentina, Brazil, and China. In the remaining countries, only about one-third of the total maize area is planted to improved materials. The relatively low presence of improved maize contrasts sharply with that of wheat in developing countries, where nearly 60% of the total wheat area (not counting that in Argentina, Brazil, and China) is planted to high-yielding varieties. The proportion is even higher for rice.

The area planted to improved maize also varies considerably by country. In Kenya, for example, over two-thirds of the maize planted is improved, compared to less than 15% in neighboring Tanzania. In many West African countries, the area planted to improved maize is well under one-third of the total, and it is generally low as well in Latin America (with the exception of Argentina, Brazil, and several Central American countries). Use of improved maize is limited in Pakistan but more widespread in India. In China and Thailand, even higher proportions of the maize area are planted to improved material.

These variations can be accounted for in part by differing levels of economic development. As shown in Figure 3, there is a positive relationship between the percentage of total maize area planted to improved maize and average income per capita (a general indicator of economic development). Even so, one observes wide deviations from the line of best fit, which can be attributed to several factors:

- Physical differences between countries that affect adoption of improved maize
- Historical factors influencing the pace of adoption
- Differences in maize research and in performance of the maize seed industry
- Differences in incentives for adopting improved maize

Homegrown and commercial seed—In addition to considering overall patterns in the use of maize seed, we examined trends in the use of particular seed types. Estimates of area planted, planting rates, quantity of seed planted, seed prices, and seed value were compiled for three categories of seed: 1) that grown by farmers for their own use, including the seed they traded among themselves, 2) commercial seed of open-pollinated varieties, and 3) hybrid seed. The first category includes all noncommercial maize seed that farmers planted and the last two all the commercial seed they bought.

Figure 2. Proportion of total maize area planted to improved maize, 1985-86.

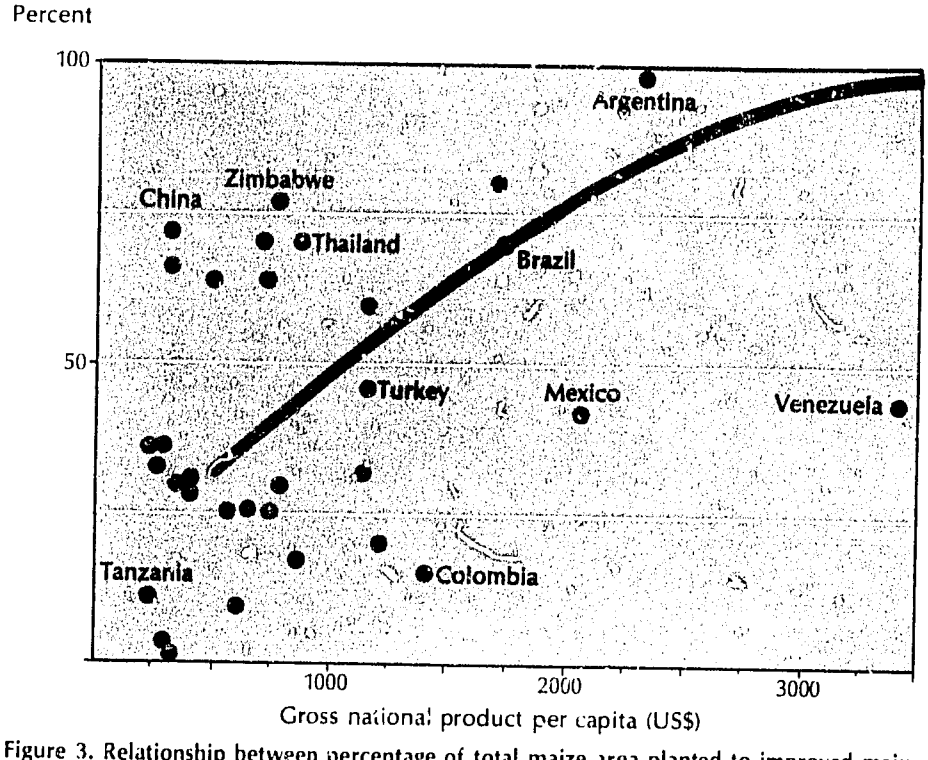

Figure 3. Relationship between percentage of total maize area planted to improved maize in 1985-86 and average income (gross national product) per capita in 1984 for some major maize-producing countries in the Third World.

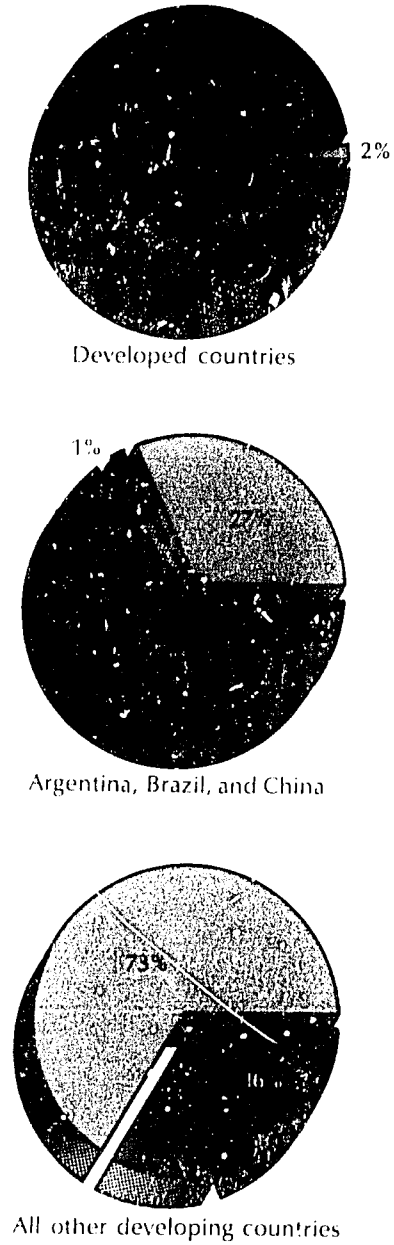

Figure 4. Proportion of total maize area planted to hybrids, commercial seed of improved varieties, and farmers' own seed, 1985-86.

In developing countries overall, hybrids occupied about 38% of the total maize area, commercial seed of open-pollinated varieties another 7%, and farmers' own seed the remainder. Eliminating Argentina, Brazil, and China, however, alters the picture considerably, reducing the area planted to hybrids to only 16% and raising that occupied by farmers' own seed to almost three-fourths in the other countries of the Third World (Figure 4). Generally speaking, hybrid maize is concentrated in the more favorable (and therefore less risky) growing areas of developing countries.

In African countries use of hybrid seed is very low, with a few notable exceptions. Hybrids are grown on about 15% of the continent's total maize area and farmers' own seed on about 75% (Figure 5). Over three-fourths of Africa's hybrid maize seed production, however, is found in Kenya and Zimbabwe. In other regions as well, hybrids are not spread evenly but tend to be heavily concentrated in a few countries.

In Thailand, Egypt, Guatemala, and Ecuador, a large share of the maize area is planted to commercial seed of open-pollinated varieties. The common denominator in those countries that accounts for the widespread adoption of commercial seed is the successful development of new open-pollinated varieties by national maize research programs and simultaneous growth of viable seed industries. But that combination of events is not common, with the result that in many regions of the world (as indicated in Figure 5) commercial seed of open-pollinated varieties is planted to less than one-third of the total maize area.

The Continuum of Maize Seed Types

In studying the variable patterns of seed use and the conditions that shape them, we found it helpful to describe the different seed types in terms of a continuum or progression from local varieties to improved ones, followed by nonconventional and then conventional hybrids. This continuum is evidenced in the yield capability of the seed types and in the technology employed to produce them, both of which topics are covered in this section.

Production of any type of commercial maize seed is a complex process, both in seed-growing fields and seed enterprises, and requires considerable understanding, skill, and experience. Even so, there are definite gradations in difficulty, the production of hybrids being more technically sophisticated than that of open-pollinated varieties.

It is not within the scope of this publication to describe all the tasks involved in commercial seed production. Our aim, rather, is to provide enough description to give readers a sense of the differences in complexity between various seed technologies. Some additional information is given in the boxes on pages 6 and 11 primarily to account for differences in the cost of various seed types. For more details, we refer readers to the following publications on maize seed production: Jugenheimer (1976), Sprague (1977), Fehr and Hadley (1980), Douglas (1980), Wedderburn and Chatha (1982), FAO (1982), Gregg (1983), and CIMMYT (1984).

Beyond tradition: Improving OPVs— Maize seed has traditionally been grown in farmers' fields as *open-pollinated local varieties*, which are still extensively cultivated in the Third World. The breeding and maintenance of local varieties is managed by the farmers themselves. At harvest (either in the field or in seed storage), they select ears from the plants that have performed best according to their own special criteria, including grain yield, freedom from disease, plant height, kernel color, forage yield, and size of ear. The selected ears are dried and stored on the farm for planting in the next crop cycle. Sometimes, growers exchange seed from the best crops in a district.

Under farmers' care and management, the maize plant has undergone much improvement in its capacity to satisfy human needs. With the advent of modern plant breeding, though, the selection process has been made more systematic and efficient and led to the development of *improved open-pollinated varieties*. The various plant breeding procedures for developing and releasing those materials are described by Sprague (1977), Paliwal and Sprague (1981), Vasal et al. (1982), and CIMMYT (1984). The products of this type of breeding continue to be released and have been adopted by many farmers in some countries (Thailand, for example, where the Suwan varieties have come to be widely cultivated).

An important difference between the handling of open-pollinated local varieties and that of modern improved maize lies in the regulation of cross pollination in the crop. Normally, the pollen shed from a maize plant's tassel (the male structure) fertilizes the ear or ears (female structure) of some other plant. The pollen is most likely to travel no more than a few meters to its recipient plant but can be carried much greater distances by strong winds. In traditional cultivation of local varieties, little effort is made to control cross pollination. As a consequence, much intermixing of varieties (contamination) takes place in a particular district.

In the production of improved maize seed, on the other hand, measures are taken to prevent contamination and ensure that seed of a variety remains *true to type* (that is, its genetic makeup does not vary significantly). To maintain varietal purity, producers must grow seed in fields that are either isolated from other maize fields or planted at a different time. They also have to remove (rogue) off-type plants and avoid mixing seed.

Farmers who acquire seed of improved varieties can maintain its purity from one crop cycle to the next if they allow the crop to intermate naturally and protect it from contamination by foreign pollen. In many maize-growing areas of the Third World, however, farmers permit considerable intermixing, often causing rapid degradation in the genetic quality of second and later generations of purchased seed. The seed retained by farmers may also show lower germination and poorer performance than commercial seed unless measures are taken to maintain seed quality, such as proper storage and protection against diseases and insects.

Hybrid maize: More complex seed technology—Maize hybrids, like improved open-pollinated varieties, are products of modern plant breeding and the science of genetics, but their production involves a more sophisticated form of controlling cross pollination. Rather than leave maize plants to spread their pollen indiscriminately, hybrid seed producers make selective crosses between genetically diverse families, varieties, or lines. The result, under certain conditions, is a quantum leap in productivity over the yield levels of open-pollinated varieties, that derives from a phenomenon referred to as *hybrid vigor*.

Selective crossing is performed in isolated plots, often by means of detasseling. Plants from which the tassel has been removed for hybridization are designated as females and produce only hybrid seed. The female parents in a hybrid combination receive pollen from male parents, or pollinators, which retain their tassels and do not produce hybrid seed.

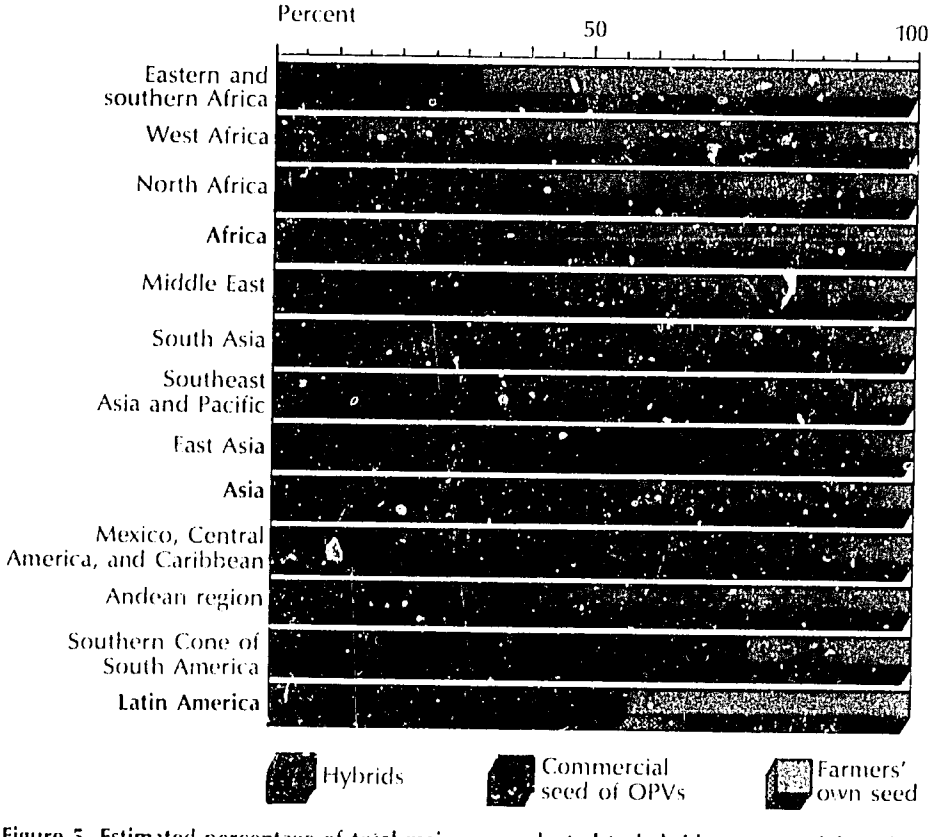

Figure 5. Estimated percentage of total maize area planted to hybrids, commercial seed of open-pollinated varieties (OPVs), and farmers' own seed in various regions of the Third World, 1985-86.

In the production of commercial hybrids, seed of the male and female parents is planted in adjacent rows in a seed production block. The ratio of male to female rows may vary, depending on the male parent's likely level of pollen production. Before flowering all the plants in female rows are detasseled and pollinated from the adjacent male rows. The seed produced in the female rows is thus a cross between the two parents and constitutes the F1 (first filial generation) hybrid. (See the box on page 6 for additional details on hybrid seed production.)

Hybrids can be divided into two broad categories, *conventional* and *nonconventional*. These offer plant breeders and seed enterprises a wide range of choices in the development and production of hybrid seed.

Conventional hybrids result from the union of inbred lines, which are created through self-pollination, usually for three or four successive generations. These genetically pure lines are usually uniform, short, weak plants characterized by much-reduced yields and greater susceptibility to adverse environmental conditions. Their poor performance has important implications for the yields and risks involved in hybrid seed production and, consequently, for the costs of seed growing.

Generally, the more inbreeding a line has undergone, the lower its seed yield. Since hybrid seed is harvested from the line designated as female, the one chosen for that purpose is often the better seed yielder of the two parents that form *single-cross* hybrids. Seed yield is boosted considerably in *three-way crosses*, in which a pure inbred serves as the male and a single cross as the female, and can be even higher in *double crosses*, which are developed from two single crosses. The heavier pollen shedding of the male parent in a double cross accounts for the better seed production of this hybrid type, the formation of which is illustrated in Figure 6.

Use of conventional hybrids varies greatly around the world. In the USA single crosses are the most common type by far, having displaced double and three-way crosses during the 1960s. Both single and three-way crosses are now widely grown in most other developed countries that produce significant quantities of maize.

Single crosses are much less commonly grown in the Third World, though a very famous one, SR52, was released in Zimbabwe during 1960 (Seed Co-operative Company of Zimbabwe) and became one of the first single crosses to be made commercially available. SR52 was widely adopted in Zimbabwe and exported to other countries of eastern and southern Africa as well. More recently, three-way crosses have gained importance in Zimbabwe and permitted an expansion of hybrid production into some of the more difficult maize-growing areas of the country.

In most other developing countries where sizeable areas are planted to hybrid seed, double crosses are the type most widely grown. Over half of Brazil's maize area is planted to double crosses, and they are also the most common conventional hybrid in Mexico and Central America. In India all of the main types are produced and marketed, though double crosses predominate. Both double-cross and three-way hybrids are commonly grown in Southeast Asia and China.

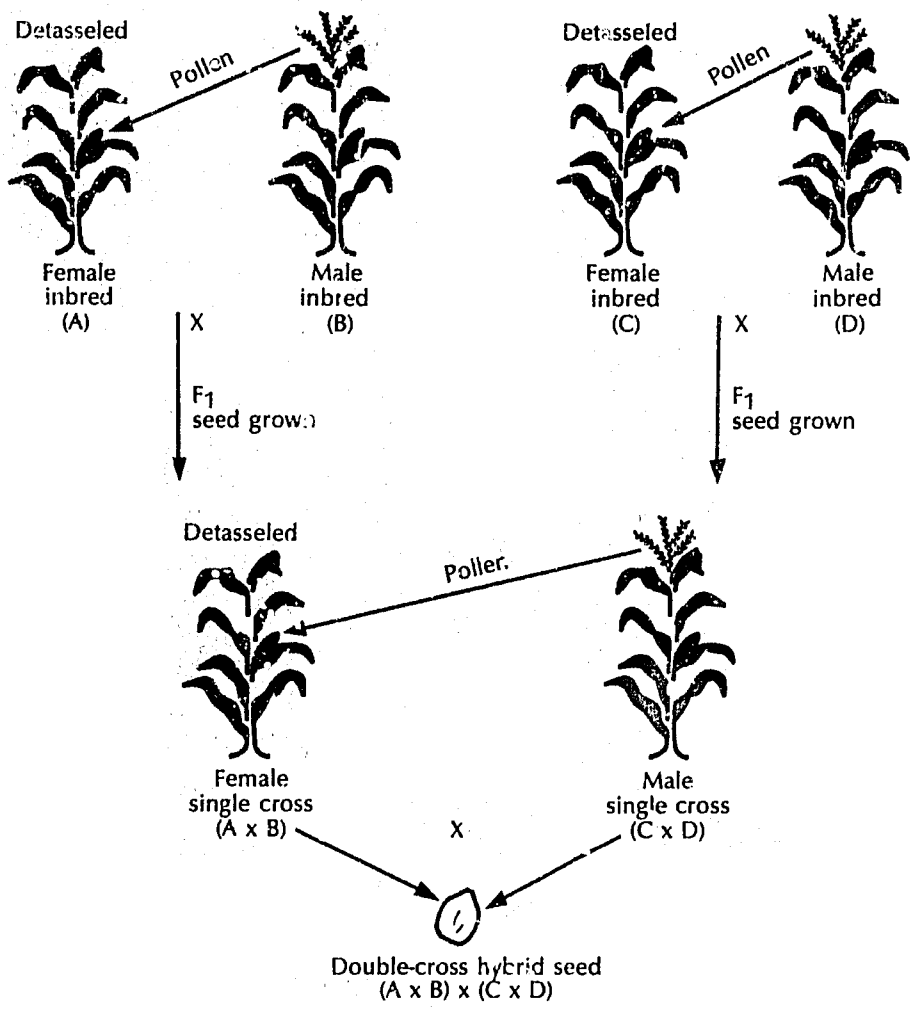

Figure 6. Production of a double-cross hybrid.

Production of Hybrid Maize Seed

Although the cultivation practices employed in growing commerical seed are more or less the same as those in maize grain production, the former involves a number of steps that complicate crop management and raise the cost of the final product. Hybrid seed production in particular demands much greater levels of supervision, crop management, and technical support. One of the complicating factors in hybrid seed production is that plants of the inbred lines are weaker than the offspring derived from a cross between them and thus require very careful management. For that and other reasons hybrid seed production is usually undertaken on selected farms by growers that have shown above-average performance in crop management.

One of seed growers' primary concerns is to minimize contamination by pollen from other maize fields. To do so, they must isolate the seed plot of each hybrid, typically by a distance of 200 m, from any other maize field. As a further precaution, they sometimes encircle the seed field with a specified minimum number of male rows that serve as a barrier against pollen. Usually, the greater the distance between the seed field and other maize fields, the lower the number of barrier rows can be. One common means of isolating seed fields, particularly in regions where land settlement has diminished field size, is for the seed enterprise to contract with groups of neighboring farmers for growing seed of a particular hybrid.

In the need for isolation and in other respects, production of seed of open-pollinated varieties is similar to that of hybrid seed. A critical difference between the two, however, is that hybrid seed production requires special crop management to achieve optimal synchronization of pollen shedding by the male parent and silking by the female.

Ensuring that maximum pollen shedding coincides with silking is a key requirement for good seed yields, which are the chief aim of growers' decisions about the time of planting. If the male and female parents flower at different times, growers have to delay planting of the male, in some cases by as much as 10 days. Hybrids in which the male parent would have to be planted before the female are not recommended because untimely planting of the latter would increase the risks of lower seed yield. Normally, delays in planting are decided according to accumulated growing degree-days and are based upon careful testing of the parents to establish their time to flowering. Other crop management practices are used to achieve optimal synchronization as well, such as differential fertilizing and watering.

Another important difference between production of open-pollinated variety seed and hybrid seed is that the latter can involve detasseling of the female rows, which makes this enterprise considerably more demanding. The operation starts at tassel emergence and continues until all female tassels have been removed, often as long as two weeks later. Normally, passes are made along each row every day, although the frequency of passes will vary according to the rate of tassel emergence, the time from tassel emergence to pollen shedding, and the method used (manual methods requiring more frequent passes than mechanical detasseling). In developing countries virtually all detasseling is done manually because labor costs are low; while in developed countries, usually one or two passes are made with mechanical detasselers, and the early, late, and missed tassels are removed by hand. Some seed companies induce male sterility in the female rows through well-established breeding procedures. In any case seed growers must inspect fields daily, and external quality control agencies normally inspect them at least twice to ensure that the percentage of pollen-shedding females is below the required limit.

After the inspections have been made, the only other major operation performed before harvest in hybrid seed fields is removal of the male rows after pollen shedding. The purpose of this step is to reduce the chances that seed from male plants will be mixed with that from females at harvest, an occurrence that would sizeably reduce the performance of crops raised from that seed. Generally, the male rows are cut while the maize is still green and used as forage or left to rot in the fields, although in some developing countries they are allowed to mature and the ears picked for grain. If picking is done by hand, it is less likely than with mechanical harvesting that male ears will be mixed with females, though there is still some risk of inadvertent seed mixture.

A detasseled female row (center) in hybrid maize seed production. The tassel on the plant at far right has been retained for contrast.

Conventional hybrids account for only part of the hybrid production in Third World countries. Various types of nonconventional hybrids are produced as well. These are formed through crosses in which at least one parent is not an inbred line, as in a cross between an inbred and a variety or between two varieties that are sufficiently different genetically to show hybrid vigor. When a variety (generally used as a female) is crossed with an inbred line serving as the male parent, the resulting hybrid is referred to as a *topcross* (Figure 7). A cross between two varieties, one designated male and the other female, is a *varietal* hybrid. Typically, the nonconventional types show less hybrid vigor than the conventional ones, but they can be developed and released in a shorter period, since less or no time is spent in the development of inbred lines (Sprague and Eberhart 1977). It also takes less time to identify a superior nonconventional hybrid once crosses have been made, and seed production is simpler to manage and less risky, with lower costs per unit, than in the production of conventional hybrid seed.

Those advantages help account for the popularity of nonconventional hybrids in numerous developing countries (most notably Brazil, Colombia, India, and Kenya), which seem to favor the topcrosses. Though less commonly employed, varietal and family hybrids have acquired special importance in Egypt, Guatemala, and several other countries.

With any type of hybrid, farmers are not likely to realize the full benefit unless they purchase new seed for each crop cycle. The yield of second- and later generation seed may drop sizeably below that of the F_1, sometimes by as much as 15-25% (Jugenheimer 1976). The decline is not as pronounced with nonconventional hybrids as it is with conventional types. In spite of the yield difference, though, many farmers in developing countries do plant seed of the F_2 and subsequent generations, especially in low-yielding environments and where yields fluctuate greatly from year to year. Under those circumstances, it may not be readily apparent to farmers that the yield of F_2 seed is any lower than that of the F_1, especially if they are growing nonconventional hybrids.

From this review of seed technologies, it should be clear that seed production ranges widely in complexity from local varieties to conventional hybrids. Another trait in which one can discern a continuum of seed types is in the degree of heterogeneity of the genotypes, a trait that has an important effect on the crop's susceptibility to various stresses. The seed of single-cross hybrids is homogeneous; all plants grown from that seed will have the same maturity and possess the same resistances and other useful traits with which the hybrid has been endowed by plant breeders. Three-way and double crosses and the various types of nonconventional hybrids are somewhat more heterogeneous and improved open-pollinated varieties even more so. The highest degree of heterogeneity is observed in local varieties that are subject to considerable intermixing.

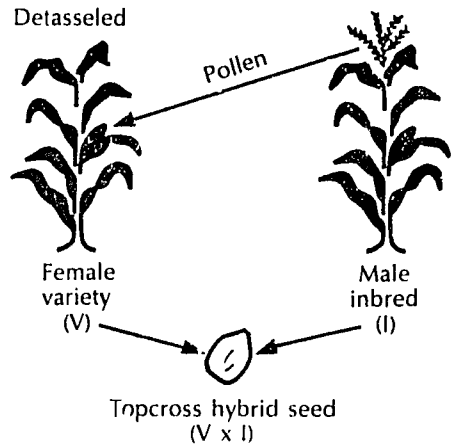

Figure 7. Production of a topcross hybrid.

Because of their genetic diversity, those varieties may possess a kind of buffering capacity that helps them withstand various stresses. Whatever resistance they have is not uniform throughout the crop, however, so that some plants may escape damage while others do not. In a single-cross, on the other hand, the genotype's resistance (to a fungal disease, for example) will exist in every plant, protecting the entire crop from damage. But if a new strain of the disease develops against which the resistance is not effective, the extreme homogeneity of the hybrid may make the entire crop vulnerable to damage, putting the farmer's yield at considerable risk. That is why single crosses tend to be most widely used in regions where stresses are not extremely severe and where various means are available for combatting them.

Determinants of seed yield—It was obvious from our discussions with numerous seed growers and seed enterprise staff that there is a high risk of seed yield loss, the hazard being much greater in production of conventional hybrids than in open-pollinated varieties. Among the conventional types, the greatest risk is incurred with single crosses and the least with double crosses. The risk entailed in production of nonconventional hybrid seed also varies according to type but is generally less than that of conventional hybrids.

Ultimately, seed yield has an important effect on the cost per kilogram of maize seed produced. Four main factors determine seed yield: 1) management and growing conditions, 2) yield potential of the seed parent, 3) planting patterns, and 4) cleaning and discard percentages.

Subtle changes in growing conditions can have a sizeable impact on maize seed yields, especially of inbred parents. To reduce the chances that seed parents will be subjected to yield-damaging stress, seed enterprises typically set up their operations in the most favorable maize-growing regions of a country (though maize seed is grown in widely varying environments) and within those areas attempt to contract with farmers of above-average skill.

Planting pattern is also clearly an important determinant of the total amount of maize seed that can be harvested from a given area. In producing open-pollinated seed, growers most often plant the whole field (within isolation limits) and normally harvest the entire crop. With hybrids, though, only a reduced proportion of the field produces seed, since the parents are grown in rows of females, from which seed is harvested, and males, from which it is not. The harvested area is further diminished if pollen barrier rows are used.

Parents of most single- and three-way cross hybrids are planted in a female to male ratio of 3:1 or lower. With most double-cross and nonconventional hybrids, in contrast, the ratio is 3:1 or higher. Four female rows per male row is an arrangement widely used in Brazil, Egypt, El Salvador, India, and Portugal, whereas the 3:1 ratio is more commonly employed in Colombia, Kenya, Mexico the Philippines, and Zimbabwe. In the USA seed growers often employ a 4:2 ratio, with narrower male rows. That increases the density of female plants, while ensuring that they are no more than two rows from a pollinating male.

With any of those planting patterns, a certain amount of land is occupied by male rows and therefore is not yielding seed. Suppose, for example, that seed is being produced on a 40-ha rectangular field and that the female-to-male ratio is 3:1, with six encircling pollinator rows. Given that the pollinator rows alone occupy 2.5% of the land, only 72% of the total area is planted to female rows and produces seed. With a 2:1 ratio, that figure would be 65% and with a 4:1 ratio 77%.

Seed yield is also reduced (by an average of about 10% for all the enterprises that provided us with information) through roguing, discarding of poor, diseased, and off-type ears, as well as cleaning and grading to remove small and broken seed. Cleaning and grading percentages are about the same for hybrids as for open-pollinated varieties but may vary greatly according to the growing area, season, and crop management practices. In commercial seed production, seed lots are discarded if they fall below the minimum germination, purity, and other standards maintained by the seed enterprise or government. Those standards and the way they are implemented vary considerably between countries and even between seed enterprises within a given country.

To get some indication of the cumulative effect of the various factors discussed here, we estimated seed yields per total (gross) hectare as a percentage of the grain yield of an improved variety (Table 1). Although they are only approximations, the percentages do give an idea of how the various seed types compare on the basis of seed yield. Generally, yields are much lower in the production of single-cross hybrids than of other hybrids because both parents of the former are inbreds. Among the other types, seed yields of double and three-way crosses, whose female parent is a single cross, normally exceed those of most nonconventional hybrids, especially the ones in which the female parent is not a single cross. Relative seed yields do vary considerably, however, and one can expect to observe sizeable deviations from the general patterns appearing in Table 1.

A somewhat surprising trend emerged in seed yield data from selected developing country enterprises that grow seed both of open-pollinated varieties and hybrids. Those data indicate that the average seed yields of certain types of hybrids are higher than those of improved varieties (Table 2). One possible explanation is that many

Table 1. Hypothetical seed yields of various maize seed types in relation to grain yields of an improved open-pollinated variety

	Seed yield as a percentage of grain yield of improved variety	
	Per hectare of females[a]	Per total (gross) hectare[b]
Grain yield of improved variety	100	—
Seed types:		
Improved variety	85	82
Nonconventional hybrid	81	63
Double-cross hybrid	89	68
Three-way cross hybrid	89	64
Single-cross hybrid	34	24

a Assuming a 15% loss for roguing, discarding, and cleaning. For single crosses the seed yield per hectare of females is assumed to be 40% of improved variety seed yield, for nonconventional hybrids 95%, and for double and three-way crosses 105%.

b Assumes a 3.5% loss in land area for pollen barriers in hybrid production (and equivalent perimeter unharvested for improved variety), 4:1 planting patterns for nonconventional and double-cross hybrids, and 3:1 for three-way and single-cross hybrids.

seed enterprises concentrate more of their efforts on production of hybrid seed and that, as a result, improved varieties fall below their potential in seed yield. Another is that seed of some of those varieties is being grown in environments to which they are not well adapted. In Kenya, for example, it has proved to be more efficient to produce seed for lowland environments in the country's highlands, close to maize seed production facilities.

The performance of seed types— Farmers, like seed producers, assess the yields of different varieties and hybrids and are attuned to differences in their performance and in the risks incurred by growing them. Of course, the yields of hybrids and other maize types vary considerably according to environmental conditions, management practices, and the genetic makeup of the commercial seed. Even so, the evidence available suggests that, across the whole spectrum of growing conditions, the various seed types show a general progression in productivity, as follows: local varieties, improved varieties, nonconventional hybrids, double crosses, three-way crosses, and single crosses.

This pattern is manifested most distinctly (and hybrids are likely to display their superiority most clearly) when the seed is grown under extremely good growing conditions. That conclusion is evident in these data from US trials in which average yields were around 10 t/ha:

	Percentage of OPV yield
Open-pollinated varieties	100
Top-cross hybrids	115
Double-cross hybrids	126
Three-way cross hybrids	128
Single-cross hybrids	133

Source: Adapted from Jugenheimer (1976).

From those figures and other information we obtained informally, it appears that single crosses show a yield advantage of about 30% over improved varieties having the same genetic base under very favorable experimental conditions.

The yield gap between those two types of maize may be narrowed substantially outside the temperate zone. Based on yield data from experiments conducted at 12 locations (representing a number of different environments) in Mexico and Central America, we ranked the various maize types considered in this study as follows:

	Avg. yield (kg/ha)	Percentage of OPV yield
Open-pollinated varieties	4894	100
Varietal or family hybrids	5324	109
Double-cross hybrids	5351	109
Three-way cross hybrids	5551	113
Single-cross hybrids	5594	114

Source: Calculated from Cordova (1986).

In these experiments the difference in yield between single-cross hybrids and open-pollinated varieties was less than half of what it was in the US trials. Data from the sites in Latin America may underrepresent the yield potential of hybrids, though, considering that less work has been done to develop hybrids for those particular tropical and subtropical locations than has been conducted in the temperate zone. Even so, much the same pattern was observed by Boonsue (1983) in the performance of hybrids tested in Thailand. The average yield of the best hybrid was 18% higher than that of the improved variety in a trial with average yields ranging from 4 to 5 t/ha for various hybrids and varieties.

Those trials were carried out at experiment stations under favorable growing conditions. Under poorer crop management and harsher environmental conditions, the yield advantage of hybrids is diminished even further. In the tropics and subtropics, where farmers' average yields often do not exceed 1.5 t/ha and maize production

Table 2. Average seed yields in relation to the seed yields of improved varieties, as reported by seed enterprises in developing countries

Seed type	Average seed yield (kg/ha)	Avg. seed yield per total hectare as percentage of seed yields of improved variety
Improved variety[a]	2160	100
Nonconventional hybrid	2090	97
Double-cross hybrid	2660	123
Three-way cross hybrid	2340	108
Single-cross hybrid	1064	49

[a] The average grain yield of the improved variety was 2860 kg/ha.

is still in its infancy, differences between the yields of hybrids and improved varieties are likely to be small. Even if hybrids do show a sizeable percentage increase in yield over improved varieties, the actual difference in tons may be so small in areas where yields are generally low and variable that farmers cannot readily perceive it. In on-farm trials conducted in several developing countries, it has been observed that under difficult growing conditions there is little perceptible difference between the yields of hybrids and improved varieties. This evidence is not necessarily conclusive, however, since hybrids are not generally targetted for such harsh environments.

Nevertheless, it does seem clear from the evidence we have that the overall yield advantages of hybrids and improved open-pollinated varieties vary according to growing conditions, farmers' circumstances, and the level of maize research that has been conducted locally. In many parts of the Third World, farmers are not likely to adopt hybrids, or even improved varieties, until further improvements have been made in them, particularly in their resistance to diseases, insect pests, and environmental stresses. Those improvements should give commercial seed of various types a more readily apparent advantage over farmers' local varieties under the harsh growing conditions that prevail in developing countries.

The Cost Continuum

Some of the patterns we have described in preceding sections are reflected in the costs of maize seed production and in the prices paid for maize seed. For example, costs and prices vary widely from one region to another, as do the adoption and productivity of various maize seed types. In spite of that variation, though, we can discern a continuum of costs and prices from improved varieties to conventional hybrids. The purpose of this section is to describe the basis of and patterns in costs and prices and to examine some of the factors that account for the variation observed.

Costs of seed production—Variation in the costs of growing different seed types depends to some degree, as mentioned previously, on their relative seed yields. But that is not the only, nor even the most important, factor in the extremely complicated exercise of costing maize seed. One must also take into account the many activities that occur during the production of commercial seed from the farm and seed enterprise to the seed marketing and distribution channels. Some of the activities are described in the boxes on pages 6 and 11, and costs are given in Table 3 for selected aspects of growing and harvesting seed in developing countries and the USA.

The activities described in the box on page 11 make the growing of commercial maize seed a much more costly proposition than the production of maize grain at any given location. Likewise, it costs more per hectare to grow hybrids than commercial seed of improved varieties, since the former require more complicated field layout, planting, and harvesting, a higher degree of management and supervision, additional training of growers, extra labor for detasseling and roguing, and greater quality control. In developing countries the parent seed of hybrids generally costs 3-5 times more than the resulting hybrid seed planted for grain production.

The costs of parent seed and of some production activities are met by most commercial maize seed enterprises. Although the exact terms vary according to the seed enterprise, the contract agreed upon with a particular farmer, and the type of maize seed grown, the enterprise commonly pays for detasseling, harvesting, and transport, and almost always provides free supervision and technical assistance to seed growers.

Growing hybrid seed is much more expensive in the USA than in developing countries. The generally higher costs of crop management and parent seed in the former account for part of the difference, as do the lower labor costs in developing countries (which reduce considerably the expense of detasseling and harvesting) and the lower prices for agrochemicals. To get a more complete assessment of seed production costs, though, one would have to include with the items considered here the amounts paid to cover land preparation, land rent, financing, and other farm costs.

Table 3. Selected costs per hectare of growing maize seed

Selected items in growing and harvesting seed	Developing countries[a] Improved variety	Developing countries[a] Double-cross hybrid	USA, single-cross hybrid[b]
		$US/ha	
Parent seed	17.1	26.9	100
Fertilizer	100.0	101.4	100
Pesticides	37.0	41.5	70
Herbicides	20.0	22.5	60
Roguing	7.7	9.0	15
Detasseling	—	44.1	115
Supervision/inspection	19.5	23.6	15
Harvesting	35.9	49.2	75
Total	237.2	318.2	550

a These figures are averages for all seed enterprises in developing countries that provided us with data.
b These figures are estimates.

Harvesting, Conditioning, and Marketing Commercial Seed

As in the growing of commercial maize seed, a high degree of specialization and considerable expertise are required in the various operations that take place from the time seed is harvested until it is sold to farmers.

Commercial maize seed is normally harvested as soon as possible after it reaches physiological maturity to reduce the risk of damage to the crop from weather, diseases, and pests. At the start of harvest, the moisture content of the seed ranges from 30 to 35%. In countries where labor costs are high, harvesting is done mechanically; it is performed by hand in almost all developing countries.

After harvest the ears are taken to a seed plant, where, in separate lots for each seed field, they are dehusked and sorted to remove off-type and diseased ears, and a sample of each incoming lot is tested for moisture and viability. The ears are then dried until the grain moisture content is 12% or below. If the moisture content were any higher, there would be considerable risk of seed quality deterioration during storage, especially in warm, humid climates. In some developing countries, the ears are dried by the very labor intensive procedure of laying them in the sun and covering them at night and during rain. The more common approach in developing country seed plants is to dry the ears using either industrial fuels or the dried maize husks and cobs. With that procedure the drying temperature must be carefully controlled to avoid damaging seed. The dried seed is then tested for moisture and viability.

After drying and temporary storage (until the busy harvest season has passed), the ears are shelled, the seed is cleaned and sized, and samples are taken for germination and other quality tests. Any lot of seed that does not meet specified minimum standards of the seed enterprise or seed certifying authority is rejected. Small seed lots of comparable quality are then blended, chemically treated, and packaged. Seed is packaged either by number of kernels per bag, a common practice in the USA, or on a unit-of-weight basis, as is done in many developing countries. If seed is distributed in sealed packages, such as plastic bags, its moisture content must be very low (less than 9%) to prevent deterioration. Providing small packages of 2, 5, or 10 kg has proved very effective as a means of extending seed to small-scale farmers in many countries, including India, Kenya, Thailand, and Zimbabwe.

Packaging of maize seed at a private seed plant in Indonesia.

When conditioning and packaging are complete, the seed is stored in a warehouse under cool, dry conditions until it is transported to distributing and retailing agents. Marketing of seed is comparable in many respects to the marketing of other farm inputs. It is essential, for example, that seed be available to farmers both in sufficient quantities and at the proper time. To be sure of meeting farmers' requirements, seed enterprises carry over a certain amount of seed, usually 20-30% of the amount they expect to sell per crop cycle. This percentage may vary widely from year to year, however, especially for individual varieties and hybrids. Maize seed can be stored, with little loss in quality, for several years under cool, dry conditions, although the risk of diminished quality increases rapidly over time. For that reason companies normally strive to minimize carryover beyond one year.

Significant costs are incurred in marketing commercial seed. One of those is financing seed from the time growers are paid until money is received from retailers. Those costs escalate very rapidly with seed that is carried over for more than one cyle. Other activities that ultimately add to the cost of the seed are: informing farmers about the performance of varieties or hybrids and their use under different conditions (tasks that can be accomplished through on-farm trials and demonstrations), arranging finances, conducting research, enforcing quality standards, writing off physical and financial losses, meeting normal business requirements (such as accounting, reporting, and paying taxes), and making profits to invest in future production.

There is a less pronounced difference between the USA and developing countries in the expenses that seed enterprises incur in taking seed from growers' fields to processing plants, storage, and distribution centers. Transportation, drying, conditioning, and packaging of seed cost, on the average, only about 20% less in developing countries than in the USA (Table 4). Among developing countries, though, the costs of those operations vary widely, depending on the types of seed technologies employed, the local prices of seed production inputs, and the currency exchange rate. But within any given enterprise, some of the costs incurred after seed production are about the same for the various types of maize seed. Others, such as financing, storage, and marketing, are determined more by the value of the seed and are thus higher for single-cross than for double-cross hybrids, for example.

Value added to seed—The activities of seed growers, retailers, and others add incrementally to the value of maize seed as it passes through the different stages of the production and marketing process. The degree of value added at each stage is established by seed enterprises as they try to set prices that accurately reflect the worth of services offered by various groups and that provide them with a sufficient incentive for participating in the seed operation.

At the farm level, for example, seed prices are usually set in relation to returns from commercial maize production, so that returns from maize seed per hectare often exceed those from maize grain by 15-20%. This margin compensates farmers for the extra risk involved in seed production and reflects the relation between seed and grain yields, the price of maize grain, and the cost of production inputs. At the levels of seed distribution and retailing, prices are set to cover the costs both of producing and marketing seed, with a sufficient margin for future investment and research.

Competition imposes a discipline on seed enterprises in the way they establish prices. Where a number of firms are competing with one another, prices will reflect the relative values of different seed types. Any enterprise that sets its prices freely may lose part of its market share (if prices are over the seed's value as perceived by farmers) or gain some (if prices are below the value of the seed).

A different sort of discipline is applied to public seed enterprises or private ones that are given exclusive rights to seed markets by the government. In those cases governments usually become involved in the price setting process and require that seed enterprises justify price increases by demonstrated increases in costs. This restriction on seed prices may cause them to move out of line with commercial reality, often resulting in financial losses for public seed enterprises (which are commonly short of funds in any case) or a lack of investment by private seed enterprises.

To gauge seed values as established by seed enterprises at key points in production and marketing, we obtained from them the prices paid to contracting farmers for the seed they produce and also estimated the value of the seed in contracting farmers' fields before harvest. To determine the farm-level value of seed prior to harvest, we added to the price seed growers receive the various production costs incurred on the farm which, as mentioned previously, are covered by most seed enterprises. We also obtained prices of seed being marketed, those paid by seed distributors to seed enterprises, (wholesale prices), and those paid by farmers for purchased seed (retail prices). All costs, prices, and values were reported on a dry seed equivalent basis.

Relative seed prices—In calling attention to important patterns in the prices of different seed types, we are presenting all maize seed prices as ratios of the seed price to that of grain. This conversion allows for differences in the price of maize across countries and eliminates having to convert local prices to a standard currency. Retail prices relative to the grain price were obtained for seed of improved varieties, varietal, and topcross hybrids among the nonconventional types, and among conventional forms double-cross, three-way, and single-cross hybrids. When more than one enterprise in a particular country quoted a price for a certain type of maize seed, we took the average of the prices for that country. As seed and grain prices fluctuate over time, obviously so will the ratio between them; the ratios we report are for 1985-86.

Table 4. Selected seed enterprise costs per ton of maize seed produced (averages for all enterprises in developing countries reporting data and estimates for USA)

Selected processing activities	Developing countries, all types of maize seed	USA, hybrid seed
	$US per ton[a]	
Transport	12	4
Drying maize seed	17	19
Certification	5	1
Conditioning, chemical treating, and packaging of seed	63	96
Total	97	120

a All costs were converted from local currencies to US dollars at the currency exchange rates that prevailed during the period for which data were reported.

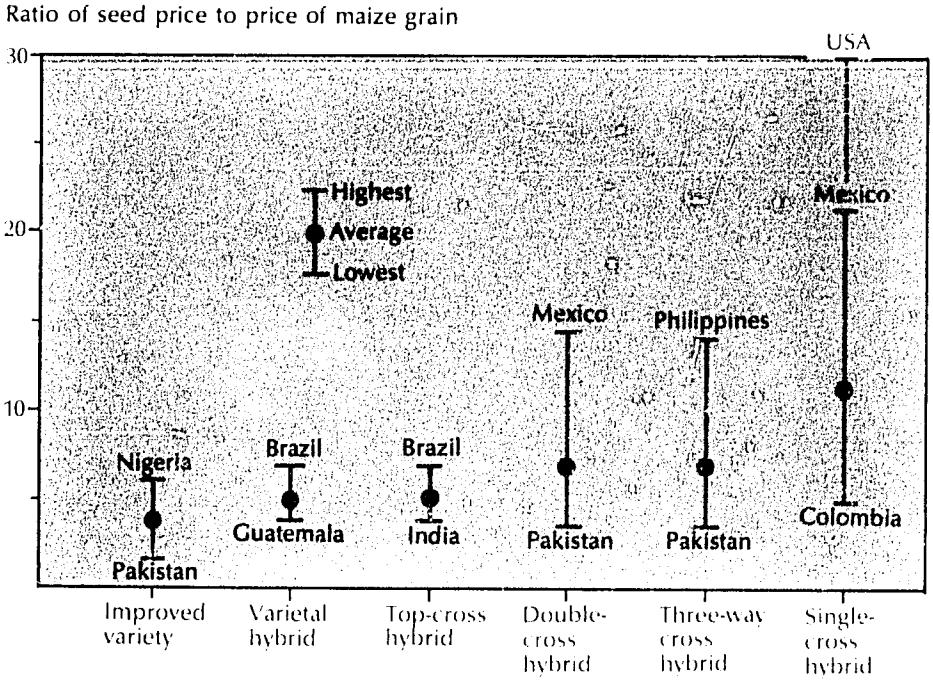

Figure 8. Ratio of maize seed price to price of maize grain, by seed type. Note the wide variation between countries in the prices of different seed types.

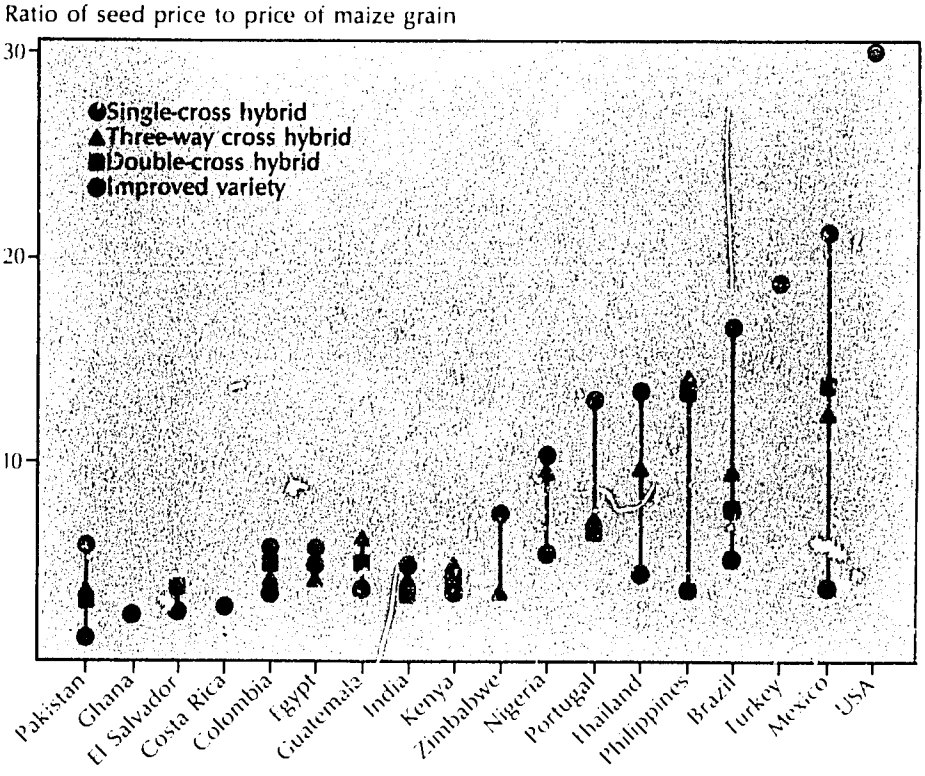

Figure 9. Ratio of seed price to price of maize grain, by country. There is a distinct progression in the price of various seed types, that of improved varieties being lower than the price of hybrids.

As in other aspects of seed production and economics, we observed wide variation between countries in the prices of different seed types (Figure 8). In Colombia, for example, the average price of single crosses was less than 5 times the price of grain, whereas in the USA the figure was 30 times. Such large discrepancies in price are explained to some extent by large differences in seed enterprise input costs, such as wages, interest rates, and retailers' margins. Another consideration is that in some countries seed prices are kept artificially low. In Pakistan, for example, the prices of seed of improved varieties exceeded the grain price by only about 30%, providing little financial incentive for seed distribution and retailing. Very low prices for some seed types in a particular country sometimes correspond to very widespread use of those types. In Zimbabwe, for example (where, as mentioned previously, hybrids are extensively cultivated), the price of single-cross hybrid seed was about 7 times the price of grain, compared to an average of 19 times the grain price for Brazil and Mexico.

Notwithstanding the price variation among countries, one observes a distinct progression in the price of various seed types, that of improved varieties being lower than the price of hybrids. Among hybrids the seed of single crosses was the most expensive, followed by three-way crosses, double crosses, and nonconventional hybrids (Figure 9). Surprisingly, though, the average price of the nonconventional forms was only around 20% higher than that of seed of improved varieties, and in general price margins between various types of maize seed were narrower than we had originally anticipated.

These fairly small margins derive in large part from the circumstances of farmers in the Third World, which shape their perceptions of the value of

maize seed. Many of those farmers are faced with difficult growing conditions and severe input constraints. As a result, when they switch from local varieties to improved ones or to hybrids, the innovation does not have as much of a discernible impact on yield as it might under more favorable conditions. In the absence of a strong incentive to change seed types, farmers will tend to be very price conscious in their decisions about seed purchases and will not pay much of a premium for hybrids if they have doubts about the quality of the seed or the advantages it offers them. Their reluctance is reinforced by the shortage of cash and difficulty of obtaining credit in developing countries.

US farmers, on the other hand, are prepared to pay high prices for maize seed because they are very conscious that good hybrids can enable them to realize additional profits at the margin. Overall, their seed costs amount to only around 6-7% of the total variable costs of inputs for growing maize. In developing countries the percentage is even lower at 3-5%. Consequently, relatively small yield increments are needed to cover the outlays for seed in those countries, and farmers will be prepared to pay much more if the seed offers greater returns through higher productivity.

In view of their difficult circumstances, however, it is understandable that many farmers in the Third World opt for the low-cost alternative of planting seed of local varieties. The average price of local varieties traded among farmers exceeded the price of grain by just over 30%, a difference that reflects storage costs, physical and financial losses, and additional costs associated with carrying and selling small lots of seed. Generally, the volume of seed traded in this manner is much lower than the amount developing country farmers grow themselves and retain for planting their next crop. The value of that seed would be slightly lower than the price of seed exchanged among farmers, since no trading costs are involved.

Another reason for the relatively small difference in price between open-pollinated varieties and hybrids in developing countries is the fairly high share of value added after seed growing. Activities taking place at the farm level contribute only about 40%, on the average, to the total value added, and the remaining 60% comes from seed enterprises and from groups responsible for distribution and retailing (Figure 10). The value added for seed growing covers the cost of all production activities up to, but not including, transportation of the seed to a processing facility. As explained in a preceding section, those costs vary according to seed type. The value added for processing represents all costs the seed enterprise incurs until it delivers the seed to distributors, and that added for retailing reflects all expenditures during the final stages of seed marketing. Though some of those costs vary by seed type, as explained previously, many do not. It costs about the same, for example, to transport, dry, condition, and package seed of open-pollinated varieties as it does hybrids.

In preceding sections we have studied various pieces of the maize seed puzzle, examining patterns in the yield capability of different seed types, in the costs of producing them, and in the prices paid for them. With this information we hope that agricultural decision makers will have a better idea how they might assemble the pieces of the puzzle into a coherent picture, one that accurately depicts the seed requirements of their countries and realistic options for meeting them.

Choosing the appropriate seed types—One of the first steps toward satisfying a nation's seed requirements is to identify the appropriate options for farmers. Should seed enterprises produce only hybrids, only improved varieties, or some combination of various seed types, including local varieties? All of those possibilities are represented in developing countries, and no single one is universally applicable. The appropriate seed types will be those

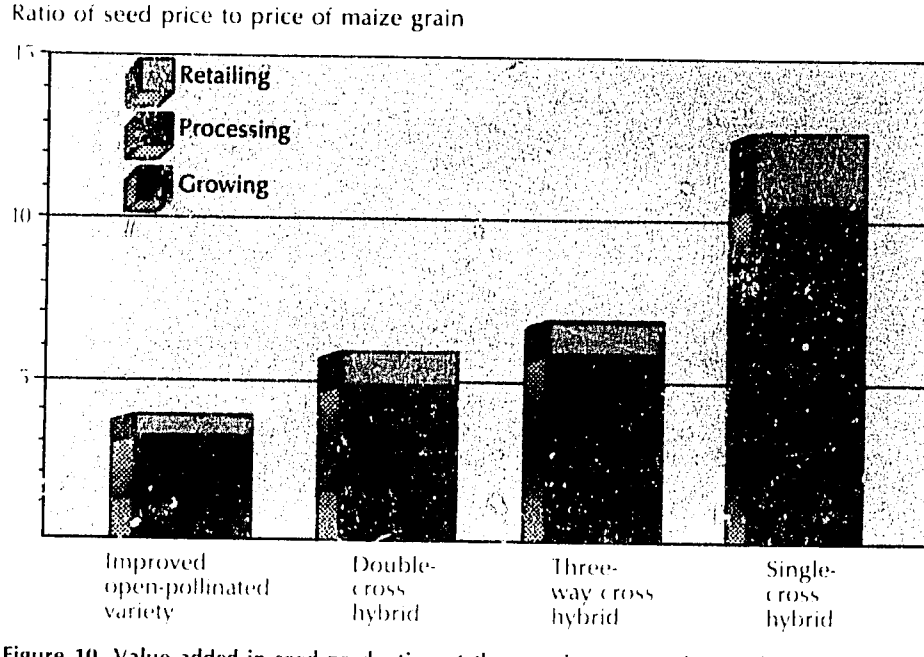

Figure 10. Value added in seed production at the growing, processing, and retailing stages (average for all developing countries studied).

that, under prevailing maize production conditions, offer farmers a clearcut advantage over other alternatives and thus a strong incentive to change seed types.

Whether farmers adopt one seed type or another is an economic choice conditioned by various factors:

- Availability of particular types of maize seed
- Grain yields likely to be achieved by the different seed types
- Prices of different seed types and their returns when planted for grain production
- Cost of inputs required for growing different types
- Risk of having to replant
- Number of years before seed must be replaced
- Cost of financing the maize seed purchase

Taking those items into account, farmers will choose the type of maize seed that seems most profitable, much as they do in making decisions about other aspects of their farming operations.

We could not, for lack of information about yields, estimate the seed price ranges at which farmers are likely to switch from one seed type to another. But we were able to calculate, by simple budgets, the yield increases that should give farmers a 100% return over the extra cost of the seed purchased, which is probably the minimum return that will provide farmers with sufficient encouragement to change seed types (Perrin et al. 1979). To the extra seed cost, we added a 100% margin for risk and the cost of capital. In determining the yield increases, we used the average seed prices given in Figure 8 and assumed average seeding rates in developing countries of 27 kg/ha for local varieties, 25 kg/ha for improved varieties, and 22 kg/ha for hybrids.

Other assumptions will be explained in a forthcoming CIMMYT Economics Program working paper by Longmire and Stewart.

The magnitude of the yield increase required to motivate farmers to choose purchased seed of improved varieties over their own seed of local varieties depends very much on the average yield of the local variety (Figure 11). If that average is only about 1 t/ha, then the improved variety would have to yield 8% more than the local variety to compensate the farmer for the extra cost of the seed purchased, plus the margin for capital costs and risk. The yield difference drops to 3%, however, if the average yield of the local variety is 3 t/ha. The difference is smaller because at this higher average yield, the extra cost of purchased seed represents a smaller proportion of the extra income per hectare that is gained from the yield increment.

Should it prove necessary to replace seed of the improved variety every two years (rather than four, as we assumed in our analysis), its yield advantage will have to be greater (by about half). That would also be the case in developing countries where farmers' planting rates are well above the average, especially if maize is grown both for grain and fodder. In some regions, such as the northern parts of Pakistan and of Turkey, seeding rates are so high that they would inhibit the purchase of certified seed by farmers even if it were widely available.

We observed much the same pattern in yield increments in considering the choice between various types of hybrid seed purchased every year and that of improved varieties purchased every four years (Figure 12). Where the average yield of the latter is only 1 t/ha, farmers might purchase single-cross hybrid seed if it shows a 30% yield advantage over the improved varieties, a very unlikely outcome, according to the maize

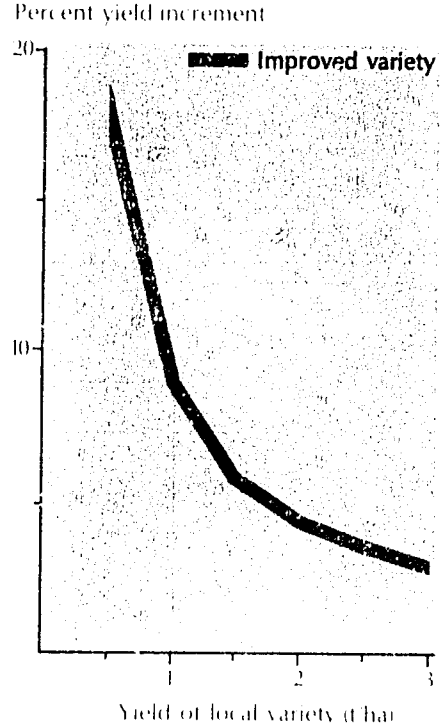

Figure 11. Increment by which yield of improved variety must exceed that of local variety to pay seed costs of purchased seed and provide a 100% margin for capital and risk.

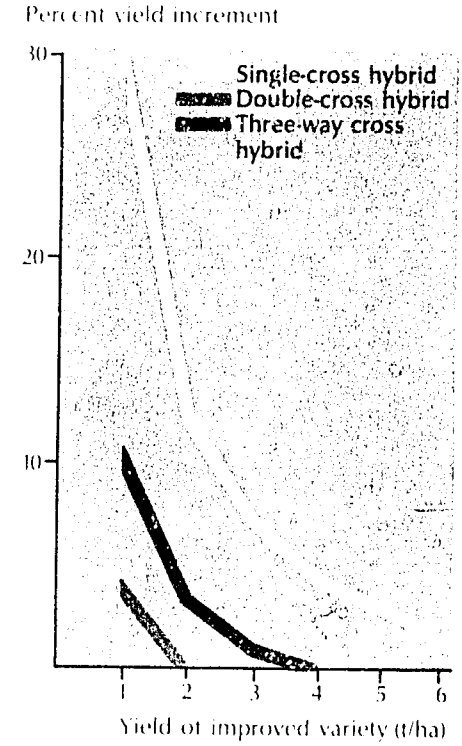

Figure 12. Increment by which yields of hybrids must exceed that of an improved variety to pay extra seed costs and provide a 100% margin for capital and risk.

specialists we consulted, with such a low average yield. If, on the other hand, the improved varieties' average yield is as high as 6 t/ha, farmers might be induced to purchase single-cross hybrid seed by a readily achievable yield increment of only 2%. The required yield difference is also quite small, even at low average yields, to make nonconventional hybrids a more attractive option to farmers than improved varieties.

The yield differences we calculated are based, as mentioned previously, on average seed prices (expressed in relation to the price of grain) and on average planting rates. To analyze the choice among seed types more specifically, we considered the cases of six countries, each having different seed prices and other conditions that influence decisions about seed. The main assumptions of these cases are outlined in Longmire and Stewart.

First, we examine the choice between various types of improved maize and local varieties in Mexico, Pakistan, and Haiti, which represent three distinct sets of circumstances in Third World seed production (Figure 13). Mexico is typical of many developing countries where both public and private seed industries produce hybrids and the prices of seed from the private sector are generally well above those of seed from the public sector. Under those circumstances farmers will not purchase private industry's hybrids unless they show a much more dramatic increase in yield over local varieties than those of the public sector. For that reason the private sector has generally concentrated its seed marketing in the country's better maize-growing regions and has penetrated the poorer areas to a much smaller degree. For those lower yielding and more risky areas in Mexico, it appears that improved varieties and lower cost hybrids are more appropriate.

Pakistan is representative of countries in which the prices of public sector maize seed are kept relatively low. Under those circumstances improved varieties and hybrids are likely to be an attractive option for farmers even at quite low yields. The difficulty is that, because prices of maize seed are so low, there is little incentive for anyone to produce and market them. An increase in price would probably stimulate production and make improved seed more widely available to farmers. In Haiti, where the seed industry is still in its infancy, relative seed prices are already high enough that seed production should increase as farmers begin adopting improved maize at a quicker pace.

In the other three cases, we compare purchases of various types of commercial maize seed, the choices considered being improved varieties or hybrids in Thailand and hybrids only in Kenya and the USA (Figure 14). In

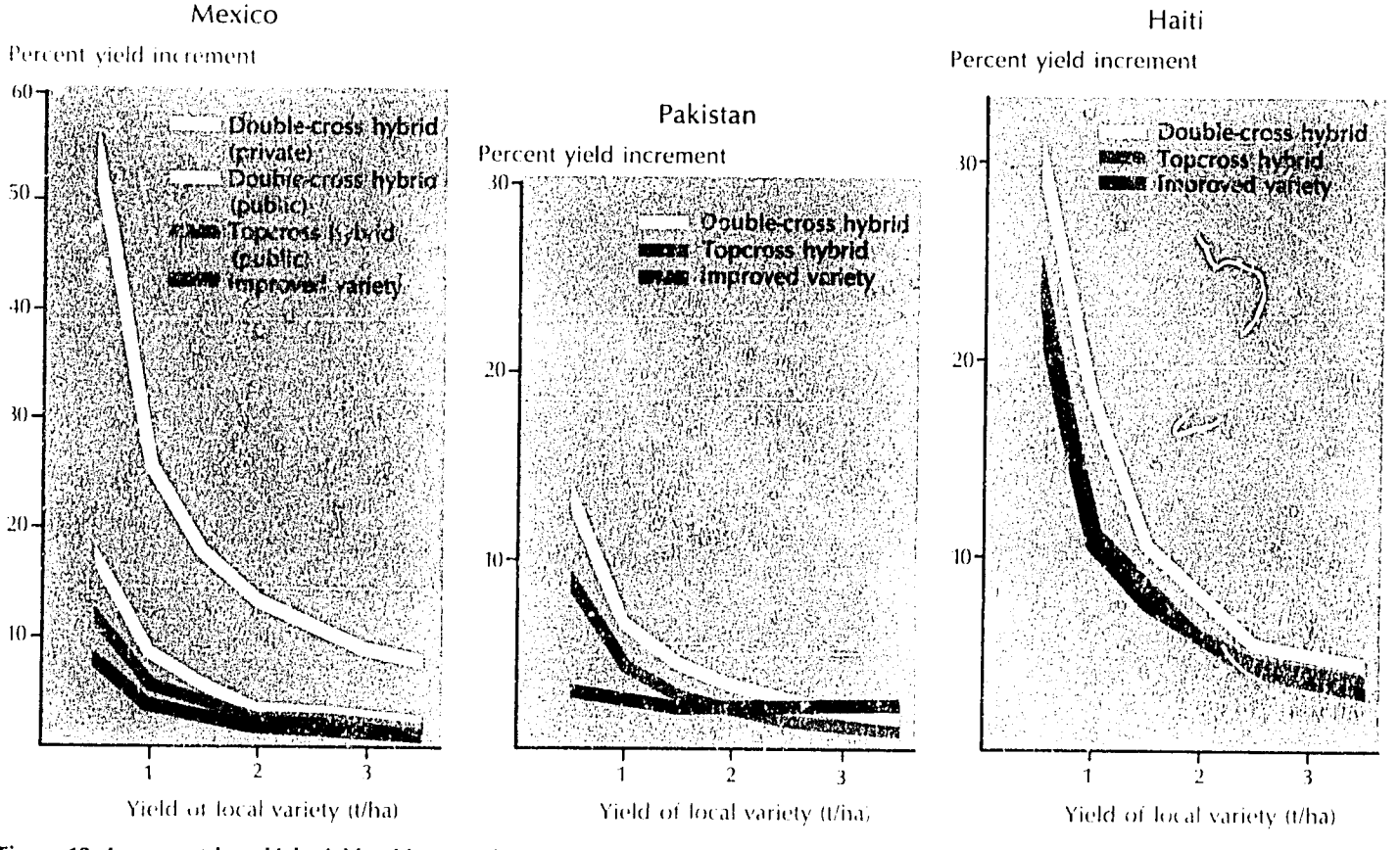

Figure 13. Increment by which yields of improved varieties and hybrids must exceed that of local variety to offset cost of purchased seed, plus a 100% margin, in selected countries.

environments where improved varieties give an average yield of 1 t/ha, Thai farmers are not likely to give up those varieties for hybrids unless the latter show a yield advantage of over 10%. It is highly improbable that they will do so as long as the average yields of varieties remain extremely low. In environments where yields are higher, though, a much smaller yield advantage should provide farmers with an incentive to purchase hybrids. Other considerations may enter into farmers' decisions, as is well illustrated by circumstances in Thailand. It appears that hybrids are not being extensively adopted in the country, partly because resistance to downy mildew (which reaches epidemic proportions periodically) has not yet been widely incorporated into inbred lines, whereas it has been present for some time in the improved varieties. Another reason that Thai farmers are not adopting hybrids more rapidly is that many run a high risk of having to replant because of lack of moisture.

In Kenya, which has a fairly lengthy history of hybrid development, farmers will have an incentive to switch to single-cross hybrids if they yield 5% more than double crosses, assuming that the average yield of the latter is 3-4 t/ha. In the USA, where seed prices are much higher than in Kenya, farmers can be expected to adopt single crosses that show a 5% yield increment over double crosses only if the average yield is at least 6 t/ha. Since yields now average 7.5 t/ha in the USA, farmers have a more than sufficient incentive to adopt single crosses and have been doing so for some time.

A public or private seed sector? – Having identified the appropriate seed options for farmers, agricultural decision makers will have to confront a number of other issues concerning the way in which various seed types can be made readily available to farmers. One central question is the extent to which public organizations, private enterprises, or both should be permitted and even encouraged to operate in developing countries.

That question has been answered in different ways across the Third World, resulting in various arrangements whereby public and private seed enterprises coexist. In most developing countries, the public sector is quite deeply involved in seed production, as indicated by some results of our survey (Table 5). That involvement takes several forms. Generally, public research agencies provide the basic seed from which commercial seed is produced and approve the varieties and hybrids to be released as certified seed. In various countries a certain portion of the maize seed supply is produced on state-owned farms, and in most countries (80% of them) some seed is produced by public seed enterprises. Nearly all developing countries also maintain seed regulatory agencies, the exceptions being those with fledgling seed industries. In contrast to the heavy public involvement in Third World seed production, none of the countries with developed market economies

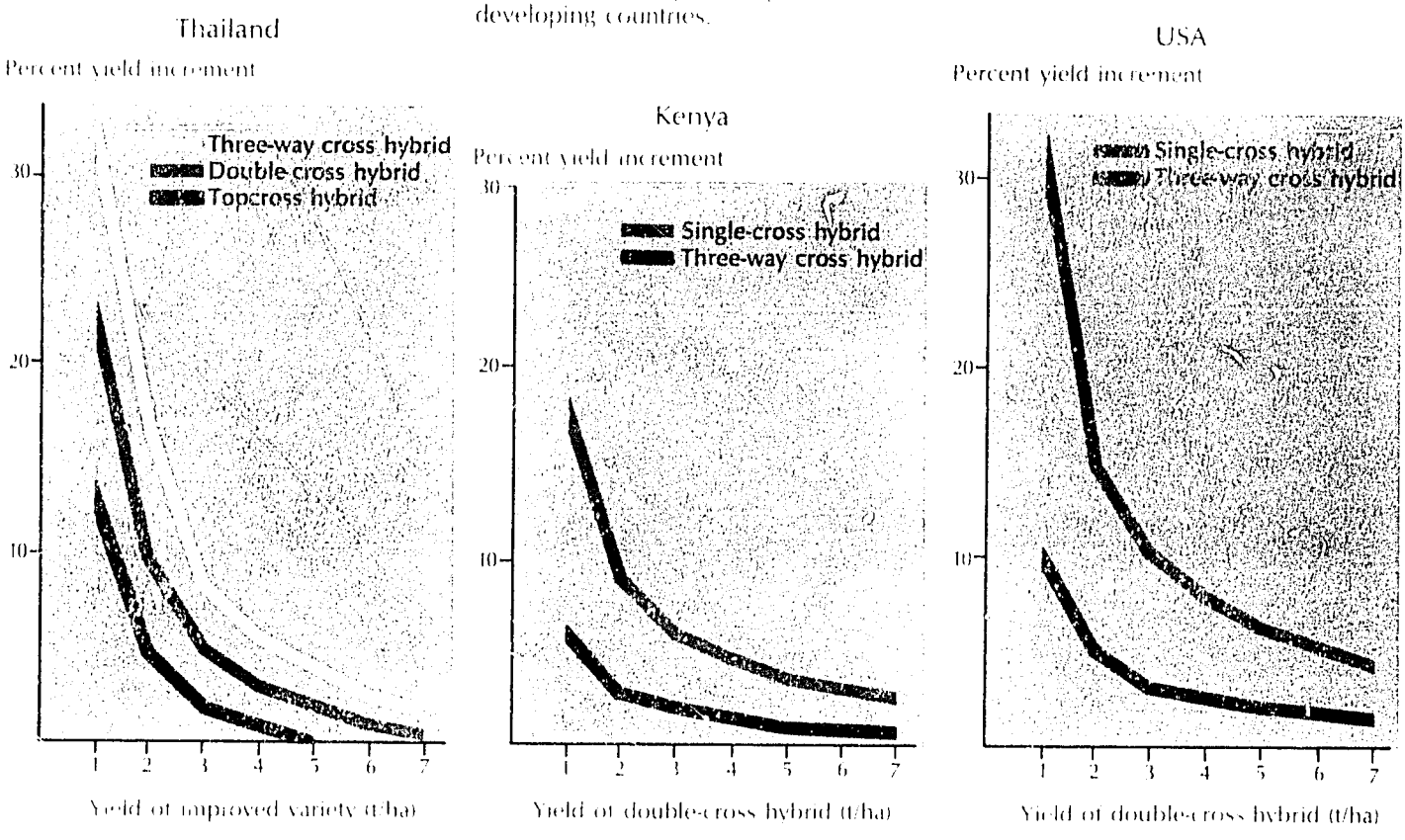

Figure 14. Increment by which yields of hybrids must exceed that of an improved variety or double-cross hybrid to offset extra seed costs, plus a 100% margin, in selected countries.

Table 5. Public sector involvement in maize seed industries

	No. of countries reporting data	Number of countries with: Seed regulating agency	Seed quality testing agency	Public seed enterprises	Private seed enterprises
Africa	12	9	9	10	9
Asia	12	11	11	11	8
Latin America	13	9	11	11	12
All developing countries	37	29	31	32	29
Eastern Europe and the USSR[a]	4	4	4	4	0
Developed market economies	7	6	6	0	7
All countries	48	39	41	36	36

[a] Includes Yugoslavia.

Table 6. The private sector's share of maize seed sales in non-centrally planned countries, 1985-86

Region	Number of countries reporting	Private enterprises' share of total sales: Seed of improved varieties	Hybrid seed	All commercial maize seed
Eastern and southern Africa	4	45	96	92
West Africa	6	9	77	61
North Africa	1	73	100	78
Total, Africa	11	57	95	83
Middle East	2	0	45	38
South Asia	3	38	63	54
Southeast Asia, and Pacific	4	69	99	73
East Asia, excluding China	2	69	38	39
Total, non-centrally planned Asia	11	62	62	62
Mexico, Central America, and Caribbean	6	66	71	68
Andean region	4	65	91	86
Southern Cone of South America	3	81	98	97
Total, Latin America	13	70	96	92
Latin America, excluding Argentina and Brazil	11	66	80	73
Non-centrally planned developing countries	35	65	92	85
Developed market economies	7	100	100	100
Total, all non-centrally planned countries	42	65	98	94

Note: Total sales of commercial seed are the sum of sales by private and public enterprises.

reported having public seed enterprises, although some (such as Greece) operate semipublic seed cooperatives.

In deciding on the extent of public and private participation in a given country's seed operations, one should consider the overall performance of the two sectors. Data we received from 35 developing countries on the volume of sales of hybrids and improved varieties indicate that, in spite of the public sector's close involvement in seed production, the bulk of the commercial maize seed is produced by private seed enterprises (Table 6). (We have excluded countries with centrally planned economies from this analysis, since all seed enterprises in those nations are public.) It is not surprising that the production of hybrid seed is heavily concentrated in the private sector. The more striking circumstance is the private sector's large share (almost two-thirds) of commercial seed of improved varieties. Only 11 out of 34 countries reported that public seed enterprises provide at least two-thirds of the commercial seed of improved varieties sold.

From those results what do we conclude about the functions of the public and private sectors in supplying farmers with improved seed? Based on their record of success, private seed enterprises clearly have an important role to play in the production and marketing of all types of maize seed. They may tend to direct their investments and operations into hybrids, being encouraged by the proprietary nature of hybrid seed, but there are a number of cases (Thailand's seed industry, for example) in which private seed enterprises are also producing and marketing seed of open-pollinated varieties.

The performance of the public sector, in contrast, has been disappointing, partly because of a lack of trained seed production and marketing personnel but also because of the structure of

incentives for public seed growers and enterprises. In some countries public seed enterprises have been so tightly restricted in setting retail prices that they have not been able to meet processing and distribution costs. Other problems have arisen from distribution of seed through public agencies whose retailing performance is very poor. There are even cases in which seed growers are paid the full price on a per hectare basis regardless of the amount of seed delivered. As long as good performance receives so little encouragement, the public sector will probably continue to fall short of expectations in making improved seed more widely available to farmers.

Pricing and incentives in maize seed production—The current weakness of incentives in many public seed enterprises does not necessarily dictate against public involvement in production and distribution of seed. Rather, it calls for a restructuring of incentives, so that the various groups involved in seed operations will be more strongly motivated to perform their tasks effectively.

Well-structured incentives are not the only factor that affects the seed industry's performance, however. Success also depends on the availability of good basic seed for producing commercial seed and on the presence of well-trained personnel and adequate seed production and marketing infrastructures. Though it is within the power of the public sector to meet any of those requirements, no one can do much about another set of important factors, namely the natural conditions that are conducive to maize production.

Even the most favorable conditions, however, along with good basic seed, excellent programs for training in seed production, and all the necessary infrastructure will not lead to viable seed enterprises unless those firms also have a sufficient incentive to gain a reasonable return on their investment. They are most likely to receive that incentive if they are permitted to set seed prices, at different stages in the production process, that provide normal commercial profits.

The price required to engage good maize seed growers will vary according to the proportion of growing costs met by the seed enterprise, the degree of additional risk involved in growing seed, and the returns from alternative crops. A premium of 10-20% over the return on other crops has been suggested by Wedderburn and Chatha (1982). That is the percentage offered in many countries, and it is considered to be the minimum amount required to draw above-average maize farmers into seed production. The value added by seed enterprises in the course of production and marketing will also vary considerably according to a number of factors, including seed quality, type of seed produced, the length of time between harvest and the peak selling period before planting, and the location of the sales outlet. In taking responsibility for establishing prices, seed enterprises are also accepting the challenge to provide seed of high enough quality that farmers (who are quite discriminating as to seed quality and performance) will become regular customers of the firm.

The freedom of seed enterprises to set prices will seldom be complete, and governments will tend to exert some control over pricing. Their participation is especially important where a monopoly on the seed market has been granted to a particular enterprise, since it will not then be subject to the discipline of competition in pricing. Of the 34 noncentrally planned developing countries that provided us with data, 22 reported that the government exercises control over seed prices. In most cases seed prices are decided upon through negotiations between the seed industry and government. Some countries, however (Mexico, for example), control only the prices of seed produced by public enterprises, leaving private firms to set prices as they see fit.

Whenever governments do take part in establishing seed prices, the criteria they apply should have a sound commercial basis. If they set prices below the costs of growing, processing, and distributing seed, private seed companies will lose money and shy away from further investment in seed production, while public enterprises will become a drain on the public purse. On the other hand, if governments were to place prices well above costs (a very rare event), farmers would be discouraged from purchasing improved maize. One antidote in that situation would be stiff competition between enterprises, which would eventually bring costs and prices down.

Government involvement in pricing need not extend to the provision of direct subsidies on maize seed. Although the practice is fairly common (it was reported by 11 out of the 34 countries that supplied us with data), we have no evidence that subsidies are necessary for creating an effective maize seed industry. On the contrary, some industry leaders tell us that subsidies may constitute an additional source of uncertainty for the seed enterprise, particularly in countries whose governments are under tight budgetary constraints. The most compelling evidence against subsidies, though, is the existence in developing countries of smoothly functioning seed industries that are commercially sound and entirely self-financed. Their experience seems to confirm that if the seed industry can supply a product that shows marked improvement over materials already available, then farmers will buy that product.

Conclusion

Early parts of this discussion underscored the tremendous scope for further spread of improved maize in developing countries; later sections called attention to some of the circumstances that have impeded its spread. Most of the responsibility for eliminating barriers to the dissemination of improved maize will have to be borne by two groups, the international community of maize researchers and decision makers in developing countries who shape their nations' seed policy.

The task of maize research organizations, including CIMMYT, is to continue striving for improvements in maize germplasm (particularly in resistance to diseases, insects, and various environmental stresses) that will greatly increase its utility and appeal to farmers in the Third World. This work is particularly urgent in the harsher maize-growing environments, where a significant amount of maize is being grown but to a large extent with local varieties. Farmers in those regions have apparently concluded that the perceptible yield advantage of improved maize is simply not great enough to compensate them for its extra cost. They are not likely to change that judgment until much more research has been done on the performance of improved varieties and hybrids in difficult environments under farmers' circumstances.

The challenge of agricultural decision makers is to help create the conditions whereby seed enterprises can deliver new products of maize research to farmers quickly and efficiently. We have likened that task to assembling a puzzle, whose components include appropriate incentives, adequate infrastructure, and well-trained seed production and marketing personnel. Such a complex endeavor necessarily involves some difficult decisions, one of which has to do with the place occupied by the private and public sectors in seed production.

Although we have noted the excellent performance of private seed enterprises in comparison with their public counterparts, we do not mean to suggest that privatization is a prerequisite for success. No such simple formula can be applied indiscriminately across the whole range of diverse conditions in the Third World. Besides, other alternatives are open to decision makers that fall short of privatization, such as restructuring incentives and adjusting procedures in national seed organizations and giving play to competition that would encourage seed industries to seek excellence in production and value for money in pricing.

In this publication we have stressed the importance of incentives primarily within the seed industry, but they have much broader implications throughout agriculture. Farmers can be encouraged to adopt improved seed if it is reasonably priced and offers tangible benefits. Whether they actually adopt it, however, depends in part on other economic circumstances, such as the prices farmers receive for their crops and the amount they pay for inputs. Governments can influence those factors directly or indirectly. In some countries official policies on pricing, exchange rates, and other matters impinging on agriculture have the net effect of providing disincentives to farmers. But just as those situations were brought about through certain policy decisions, so could they be altered by alternative policies that would boost agricultural productivity in general and adoption of improved maize seed in particular.

Whatever arrangements are worked out for providing appropriate incentives in seed production, their chief aim should be maize seed of high quality. That achievement is essential to the long-term commercial success of seed enterprises, since farmers are quite quality conscious and naturally reluctant to purchase new seed unless it offers tangible improvement. But even though farmers are the final judges of quality, seed enterprises can take various intermediate steps to ensure that quality is maintained at various stages in their operations. Many seed enterprises devote considerable resources to maintaining seed quality, and most countries have established seed quality testing authorities whose purpose is to help ensure that seed sold to farmers meets minimum requirements in germination, purity, and other standards. Tests referred to as *grow-outs* (in which seed lots are "grown out" in special plots for evaluation) are one important way of maintaining quality standards. They are regularly conducted in the USA and other developed countries but are still a rare feature of seed quality control in the Third World. Although these tests and other measures may add considerably to seed costs and are ultimately reflected in prices, they are a necessary step for maintaining the productive potential and value of the seed and for keeping a healthy margin between the returns from marketing maize seed and those from selling grain.

Creating effective seed industries and maintaining high-quality seed production would be more daunting tasks than they are, were it not for two important considerations. The first is that very successful seed enterprises have already been established on every continent in the Third World and can serve as models for other developing countries. We are hopeful that the principles upon which those enterprises are based will be instituted elsewhere. Countries such as Argentina, Brazil, El Salvador, Guatemala, Kenya, Thailand, and Zimbabwe have much to offer by sharing their knowledge and experience in seed industry development with other developing countries. One important means by which they can do so is to assist with training of personnel in the technical, financial, and economic aspects of seed production and marketing.

The second consideration stems from our observations about the existence of a continuum of maize seed types. Because of the general progression in yield, prices, and other factors from local varieties to conventional hybrids, developing countries can choose from a range of seed options, each having different benefits and costs. Thus, in attempting to provide farmers with improved seed, one of the most important components of agricultural progress, decision makers need not feel compelled to take a "great leap forward" from local varieties to hybrids but can plan for stepwise progress at a pace that is consistent with changes in farmers' circumstances.

During the early phases of seed industry development, the most prudent course will generally be to concentrate on improved varieties especially in low-yielding environments. Later, as maize-growing conditions improve, farmers should be able to perceive greater yield differences between seed types and will be encouraged to move up the seed continuum, gradually increasing their use of hybrid maize. Naturally, there will be much variation by region and type of farmer in the adoption pattern over time. As suggested by the results of this study, farmers in high-yielding environments will find it economical to adopt hybrids, whereas those in low-yielding environments will not. Maize research programs must take into account those differences in farmers' circumstances as they decide which seed types warrant the greatest investment of resources.

As Third World countries develop and alter their maize seed strategies accordingly, we expect that some will opt for nonconventional hybrids as a useful intermediate step in the development of their seed industries. Generally more productive than improved varieties, the nonconventional types are simpler and cheaper to produce than conventional hybrids and can be identified more rapidly, among other advantages.

Gearing the pace of seed industry development to overall improvement in maize cultivation will not be an easy task but will require considerable insight, judgment, and patience on the part of the various groups involved in seed production and distribution. We hope that the results of this study will give them new insights and a broader basis on which to form judgments. We are also hopeful that international cooperation, which has contributed greatly to recent advances in maize improvement (mainly through germplasm and information exchange), will also become an instrument for change in seed industries, making them a more potent force for agricultural advancement in the Third World.

Production and Trends

Global maize production in 1986 is estimated by the Food and Agriculture Organization (FAO) and US Department of Agriculture (USDA) to have been around 480 million metric tons (Mt), slightly smaller than the record crop harvested in 1985 (Figure 15). The large 1986 harvest followed sizeable maize crops in the two previous years and came at a time when worldwide production of other grains was also at near-record levels. Of the 1690 Mt of grain produced during 1986 (including 530 Mt of wheat and 320 Mt of milled rice), coarse grains made up about half. Maize was the most important of those, constituting 57% of the world total output of coarse grains (and more than a quarter of the world total grain production). The next most important coarse grain was barley (22%), followed by sorghum (8%).

Developed countries—Farmers in developed countries, including eastern Europe and the USSR, normally grow just over 60% of the world's maize. The USA is by far the most important maize producer, having contributed 43-47% of the world total during the past three years. Another bumper crop was grown in the USA during 1986, although reduced plantings, early drought in the southeastern states, and a wet harvest kept production some 16 Mt lower than the US record of 226 Mt grown in 1985. Despite attempts by US policy makers to restrict maize production in recent years, it has increased by about 70 Mt since the mid-1970s, primarily as a result of higher yields. In 1986 the average maize yield for the nation was a record high of around 7.5 t/ha, compared to about 5 t/ha during the mid-1970s.

Taken together, the eastern European countries constitute the second most important maize-producing region in the developed world, the major contributors among that group being Hungary (also an important grower and exporter of maize seed), Romania, and Yugoslavia. It is estimated that the region produced 37 Mt in 1986, compared to 28 Mt during the mid-1970s. Soviet maize production in 1986 is estimated to have been 12-13 Mt, an increase of only 3 Mt over the figure for the mid-1970s.

Production in the European Economic Community (EEC), whose major growers are France, Italy, and Spain, is expanding in response to continued strong price support. In 1986 the EEC's maize crop reached 25 Mt, compared to 16 Mt during the mid-1970s. These figures considerably understate the overall contribution of maize to European agriculture though, since a sizeable portion of the crop is grown for green forage.

South Africa is estimated to have produced over 9 Mt in 1986-87. The crop was no larger than harvests of a decade ago and much smaller than the record crop of 15 Mt grown in 1981-82. But since it is almost double the size of the drought-year harvests of 1982-83 and 1983-84, South Africa has been actively seeking to export maize again.

In Canada maize production has increased markedly, the 7 Mt grown in 1986 being roughly double the size of the maize crop 10 years ago. The area planted to maize has also doubled over the past decade partly because plant breeders have developed germplasm that enables farmers to extend the northern limits of production.

Developing countries—Since the early 1960s maize production has been growing at a more rapid percentage rate in the Third World (4% per annum) than in the developed countries (3%). In the course of that 25-year period, the

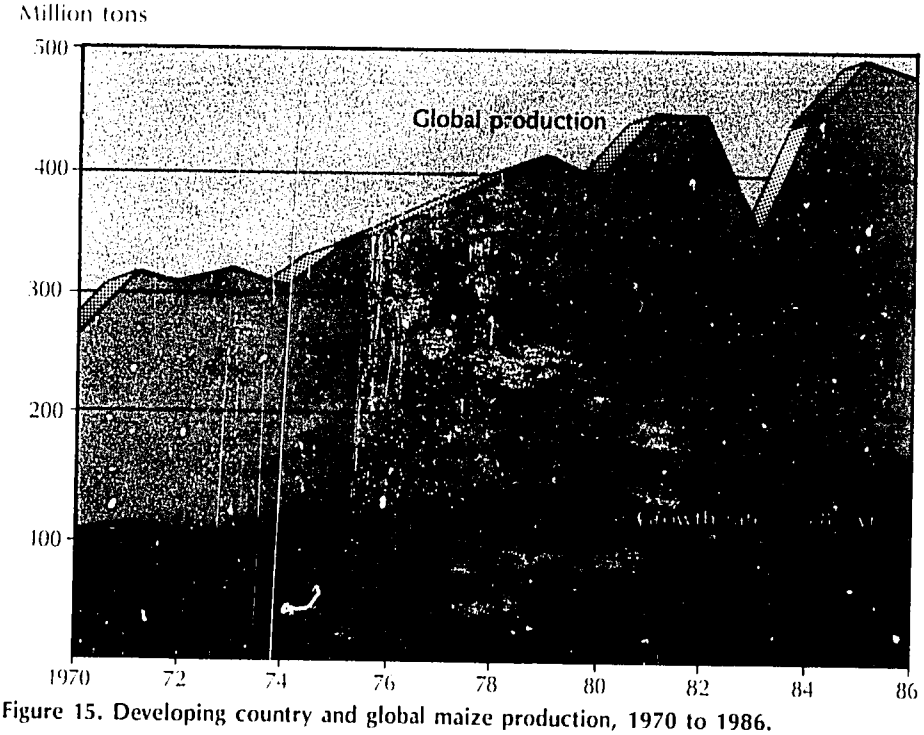

Figure 15. Developing country and global maize production, 1970 to 1986.

* Based on information available up to December 1, 1986.

annual increases in average maize yield for all developing countries (2.8%) have also exceeded those of countries with developed market economies, accounting for much of the difference in production gains between the two groups. (The average maize yield for all developing countries is around 2 t/ha, compared to around 5.5 t/ha for developed countries.) Among developing countries, though, there has been considerable variation in rates of yield improvement, with China leading the way and many countries of sub-Saharan Africa tending to fall behind. Moreover, in spite of the Third World's higher percentage growth in production, the annual increases in tons of maize produced have been approximately half those of the developed countries because of the higher share of global production in the latter.

In South America maize crops have been large during recent years. The 1986 harvest was only slightly smaller than the record crop of 39 Mt produced in 1985. Nevertheless, the continent's maize output has grown at a modest rate since the mid-1970s, when production averaged 28 Mt. Maize output has increased more rapidly in the Southern Cone than in the Andean region.

Argentina's 1986 crop was another large one, exceeding that of the previous year but falling below the record harvest of 12.9 Mt in 1981. Since the mid-1970s the country's output of maize has increased by approximately 50%, largely because average yields have risen from 2.5 t/ha to around 3.5 t/ha. Since Argentine maize growers are unprotected from the influence of international prices, however, they have suffered from serious declines in profitability during recent years. Thus, even though prices of alternative crops have also dropped, farmers will be seeking to diversify their operations, shifting from maize to other enterprises, including livestock.

Brazil's 1986 maize crop was smaller by almost 2 Mt than the record 1985 harvest of 22 Mt. Since the mid-1970s, the country's output has expanded by around 50%, with increases in yield and area each contributing about half of the total gain. Good harvests were reported for other countries of the Southern Cone as well in 1986.

Trends in the Andean region's maize output have also been favorable in the past two years, and there are signs that the long-term decline in production has been reversed. This change can be attributed in part to a greater emphasis on maize, coupled with policy and economic adjustments that are favorable to agriculture. Nevertheless, there is wide scope for further improvement of maize production in the region, where average yields are less than 2 t/ha.

In Mexico maize production has been favored by good rains during recent years, although the 1986 crop was 600,000 t less than the record harvest of almost 14 Mt in 1985. The country has increased its maize output by just under 70% since the mid-1970s, with average yields rising from around 1.2 to 1.6 t/ha. There and in Central America and the Caribbean (where maize crops have also benefitted from good growing conditions recently), the principal source of expansion in output over the past 25 years has been increased yields, which have contributed about three-fourths of the total growth in output.

Conditions in Africa were much more favorable for maize production in 1985 and 1986 than in the preceding several years. Thus, even though the 1986 maize crops in southern Africa fell short of the good 1985 harvests, they still exceeded by a sizeable margin the drought-affected crops of the early 1980s. Since the mid-1970s, maize output has increased by just over 40% in eastern and southern Africa, but population has risen by about the same amount. There is much need and scope for further improvement of maize production in that region, parts of which are referred to as the Maize Belt of Africa. Patterns in West Africa's maize output were much the same as those in the east and south. The past two years have been favorable for production, and yields have been above average in many countries of the region. The African nation with the greatest average maize yield by far is Egypt, which produced a record high of 5 t/ha in 1985. The country's 1986 crop is estimated to have been slightly smaller than the record harvest of the preceding year.

Longer term trends in sub-Saharan Africa give cause for serious concern about the continent's grain production. Between 1961-65 and 1983-85, output of cereals per capita declined at an average rate of almost 1% per annum in eastern and southern Africa and 1.7% in West Africa. Per capita maize production has also declined, though in West Africa (where maize is less important as a staple food than in the east and south) it did not fall as markedly as overall cereals output. These downward trends seem less noticeable when we adjust for the recent recovery from drought, but they still underscore the challenges of improving agriculture in sub-Saharan Africa.

China is estimated to have produced almost 70 Mt of maize in 1986 (close to the record crop of 73 Mt grown in 1984) and achieved a record average yield of nearly 4 t/ha. Elsewhere in Asia main-season maize crops were also good and overall are estimated to have exceeded the reduced production levels of 1985. An exception to this trend is that Thailand's output was about 1 Mt below the record amount of 5.2 Mt, produced in 1985-86. On the Indian subcontinent and in the Middle East, crop conditions were generally favorable during 1986.

The long-term trends in Asia's food production contrast sharply with the situation of sub-Saharan Africa. Food production per capita has increased over the past 25 years by an average of 0.7% per annum in South Asia, 1.3% in Southeast Asia, and 2.5% in East Asia. During that period China has achieved a remarkable annual increase of 2.7% in per capita output of cereals, compared with a global average of 1%. The country's rate of growth in maize production has also been very high, as indicated by the tables in part 3 of this report.

Prospects for global maize production—The weather has favored production worldwide during the past two years, and conditions for the coming crops generally appear to be satisfactory. Despite rapidly falling international maize prices, farmers have not by and large reduced the area planted to maize, partly because in many countries domestic prices are fixed internally, providing farmers with a buffer against the effects of short-term movements in international prices. In a number of countries, however, the decline in world grain prices will be reflected in 1987 crop prices, and pressure will increase to reduce plantings of maize over the next one or two years. The US farm program in particular (which is discussed below) will require that the country's farmers make large reductions in the area planted to maize.

Utilization and Trade Forecast to Increase

As a consequence of policy readjustments and changes in livestock production during the past 12-18 months, there were major declines in global utilization and trade of maize. Important pricing adjustments were made in US farm policy, for example, that discouraged exports in the short term. Since potential buyers knew that support prices would be lowered in mid-1986, they held off until then, causing US maize exports to fall dramatically. This development had major consequences for global maize trade, which from October 1985 to September 1986 amounted to only 55 Mt, compared to 67 Mt a year earlier. Global utilization of maize dropped from 437 Mt in 1984-85 to 419 Mt in 1985-86, with virtually all of the decline occurring in China, the USSR, and western Europe.

A sharp recovery in volume of maize trade is expected to occur in 1986-87 as buyers step in to take advantage of cheap maize available from all major exporting countries. Currently, the USA is offering a number of bonuses in an attempt to boost grain exports and in doing so is forcing other exporters to lower their prices or rapidly lose their export market share. Another factor that is likely to increase US maize exports soon is the much reduced real value of the US dollar in relation to most other major currencies.

Global maize utilization is also expected to increase as livestock producers and industrial users of maize take advantage of low prices. Improvements in many economies will give an added boost to utilization of maize and other grains in the production of income-responsive livestock products. However, countries that are heavily dependent on oil and other primary commodities and the most heavily indebted nations are unlikely to share in that economic growth.

Dramatic Changes in US Agricultural Policy

The US Food Security Act of 1985 brought about dramatic changes in the country's agricultural policy late during that year. The most important change was the decision to lower price supports of major cereals by some 25%, a measure that took effect in the crop marketing years beginning in 1986.

During recent years the US government has given farmers considerable price support through *loan rates* as well as income support by means of *deficiency payments* and *target prices* (Table 7). Under a series of very complicated arrangements, farmers became eligible for that support by complying with certain provisions of the program, such as taking land out of production. In a major alteration of the program, the Food Security Act of 1985 allows for the loan rates to be adjusted more flexibly, with the aim of making the USA a more competitive seller in export markets.

The loan rates for wheat, maize, and other grains have tended to underpin international prices for those crops, particularly in years when grain supplies were large relative to utilization. US grain policies have thus served as a kind of shock absorber for grain world markets. In the past loan rates were generally kept in line with US farmers' costs and displayed little movement (particularly downward) from year to year. From now on, however, loan rates will be set according to new provisions, including a moving average of market prices. During 1986 international grain prices moved downward by about the same amount as the US loan rates.

Target prices, on the other hand, which are used to provide US farmers with income support, have not been adjusted downward. As a result, the deficiency payments that make up the difference between target and market

prices have increased, leading to a sharp rise in 1986 in government outlays to farmers. The costs of commodity support payments to US farmers were over US$25 billion in fiscal year 1986.

Since there has been little change in their income support, US farmers have received almost no incentive to make adjustments in their production, and as a consequence the country has accumulated massive surpluses of commodities. Adjustments will be further discouraged during the next few years by another provision of the Food Security Act of 1985, namely that target prices will be held constant over the five-year period during which the act is in effect.

An additional policy adjustment is to reinstitute the use of various incentive schemes to subsidize the export of US farm commodities. Direct subsidies for grain were a feature of US grain policy in the early 1970s but were abandoned after the Soviet grain purchases of 1973. Some offers made in 1986 were reported to have included a direct subsidy equivalent to at least US$15/t. Such subsidies drive a wedge between US support prices and world prices, tending to force down the grain prices that other exporters can obtain and generally depressing international prices.

Despite US policy changes and a sharp increase in utilization of maize, there is expected to be a dramatic increase in ending or carryover stocks from 1986 to 1987. From 40 Mt at the end of the 1983-84 marketing year, global maize stocks will have climbed to over 160 Mt by the end of the 1986-87 year. Stocks will then be at much higher levels than when US policy makers initiated an emergency crop reduction program in 1983. Maize stocks will be at their highest level (as a share of global utilization) in the last 25 years or more (Figure 16).

Table 7. Recent maize support prices in the USA, 1980-81 to 1986-87

	1980/81[a]	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
				US$/t			
Loan rate	88.60	94.50	100.40	104.30	100.40	100.39	71.65
Target price	92.50	94.50	106.30	112.60	119.30	119.30	119.30
Farm price	122.40	98.40	105.50	127.95	104.30	90.91	72.83[b]
Export price[c]	142.00	118.00	115.00	146.00	123.00	105.00	73.83[d]

[a] July-June year.
[b] Average for July-August 1986.
[c] US gulf ports, Yellow No. 2.
[d] Average for July-September 1986.

Sources: USDA. 1985. *North America and Oceania Outlook and Situation Report*. Washington, D.C.: Economic Research Service; FAO. Various issues. *Food Outlook*. Rome; and International Wheat Council. Various issues. *Market Report*.

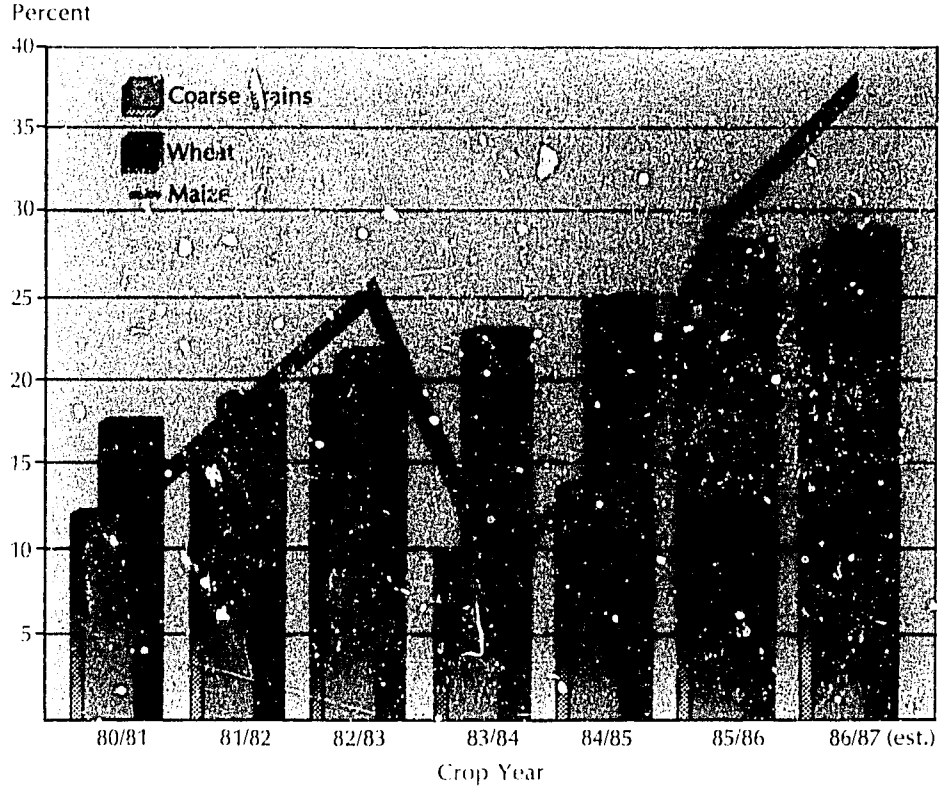

Figure 16. End-of-year stocks as a percentage of world utilization, 1980-81 to 1986-87.

The large increase in maize stocks will come at a time when other grain stocks, especially of wheat, are also predicted to rise drastically. Most of the increase in global grain stocks is occurring in the USA, placing extra burdens on taxpayers and perhaps encouraging additional policy adjustments in the near future. During 1987 the country will be holding more than 220 Mt of grain. The cost of financing this carryover, which probably has an asset value of over US$20 billion, will approach US$2 billion per annum, apart from the cost and difficulty of obtaining storage space and the additional costs incurred through physical loss of grain in storage.

Two principal options are open to US policy makers. One is to further reduce loan rates, increase subsidies on export sales, or both. The other is to cut back grain production by requiring reductions in the area planted to maize. In addition, policy makers will probably exert strong leverage on other countries, especially the EEC, to encourage them to make adjustments in their grain policies and production.

Maize [illegible]

The large buildup of maize stocks as well as the policy changes discussed in a preceding section of this report caused prices to fall sharply in 1986. During the latter half of the year, monthly export prices for no. 2 yellow maize at US gulf ports varied from 67 to US$78/t, compared to US$100/t a year earlier and an average of around US$160/t in 1980 (Table 8). Similar patterns prevailed in prices for other grades of maize, for other coarse grains, and for wheat.

Adjusted for inflation, prices have been at record low levels recently in the international grains market, and in some major currencies the drop in prices has been particularly sharp. The French franc, for example, rose by 30% relative to the US dollar between mid-1985 and mid-1986. Falling prices of grain in US dollar terms, combined with the currency effect, caused the price of maize in francs to have roughly halved from mid-1985 to mid-1986.

Grains are not the only internationally traded commodities for which prices have dropped substantially since 1980. Others are petroleum, many minerals, fibers, and various foodstuffs. The decline in prices of those items has severely limited the ability of developing countries to purchase imports.

[illegible]

In virtually every country of the world, the government intervenes significantly in agriculture. Its policies tend to favor and provide protection for some groups, sectors, industries, and regions in the economy or penalize them in the case of negative protection. Inevitably, any favors that are given to one group must be paid for by another, either through higher costs or taxes, lower income, or some other less obvious means.

In developed countries protectionism generally favors agriculture and is paid for by taxpayers, consumers, and producers of other tradeable products in the economy. In contrast, the protectionism practiced by developing countries and those with centrally planned economies penalizes agriculture, making it support other sectors of the economy (World Bank 1986). There are, of course, exceptions to these general patterns. Some developing countries have adjusted their policies in such a way as to encourage agricultural development (or at least not penalize the farm sector heavily), while some developed economies have penalized farmers by protecting manufacturers.

The *World Development Report 1986* of the World Bank and supporting analysis by Tyers and Anderson (1986) highlight the enormous costs associated with price distortions in agriculture. According to the latter study, the worldwide costs of agricultural protectionism from 1980 to 1982 added up to US$40 billion per annum on the average, an amount almost equal to the entire national income of Thailand. Nearly half of that cost is borne by developing countries, largely because their policies penalize farmers economically.

Table 8. Recent export prices of grains

	June 1980	June 1981	June 1982	June 1983	June 1984	June 1985	June 1986	December 1986
					US$/t			
Maize, US gulf ports, yellow, no. 2	114	136	117	135	149	123	103	70
Wheat, US Atlantic, soft red winter, no.2	149	136	128	136	135	133	100	116
Rice, Bangkok, white milled, 5% broken	435	530	271	269	256	222	204	195
Sorghum, US gulf ports, yellow	119	127	111	127	138	105	86	69

In addition to incurring heavy costs, agricultural policies that divorce domestic prices from fluctuations in the international market threaten the stability of world grain prices. Tyers and Anderson report that the combined impact of such policies worldwide is to make the international prices of coarse grains more than twice as volatile as they would be otherwise and rice and wheat prices four times more variable.

The costs of agricultural protectionism in developed countries have increased considerably since 1980. Policy changes in the USA have raised by a sizeable margin the costs of direct and indirect support of the farm sector, and in depressing international food prices, the USA has increased the direct and indirect costs of European farm price support programs. Recent policy changes in developing countries, on the other hand, have probably reduced the overall negative effects that earlier policies had on agriculture. Generally declining commodity prices, however, have worsened the economic situation of agriculture in those developing countries (notably exporting countries, including Argentina and Thailand) where international prices have a direct effect on farmers.

Given recent policy changes, particularly in the USA, and the resulting depression of grain prices, pricing policies in developing countries will come under strain. Nations that import food will benefit, but those exporting it will lose. Any country pursuing policies that encourage agricultural development will find that there has been a sharp increase in the costs of maintaining what were thought to be conservative prices even one or two years ago. Farmers in developing countries could begin applying pressure for their prices to be raised or held well above the prevailing equivalent world prices. In view of severe budgetary problems and indebtedness, however, policy makers will find it difficult to justify higher domestic prices when the product can be bought cheaply on the international market. Countries that maintain policies of cheap food for urban consumers will be able to do so with reduced budgetary support.

A number of countries or regions will have to cope with sizeable local carryovers of maize. One alternative is to maintain larger food reserves, but that measure involves high finance costs and may incur significant grain losses, especially in warmer, more humid environments. Another option that many countries will choose is to feed more maize to livestock and poultry and thus upgrade human diets.

The easing of maize prices that occurred from 1981 to 1985 developed into a sharp decline in 1986. With record high carryover stocks and another large crop in the northern hemisphere, it is highly probable that world maize prices will remain depressed until more is known about the northern hemisphere's 1987 crop. A large increase in utilization of maize is likely to take place over the next 12 months as greater amounts of grain are fed to livestock. Trade in maize is also expected to increase steadily because of low prices.

Many producers and exporters of maize will be asking when prices might show signs of improvement. The answer depends greatly on policy changes, general economic conditions, and crop production in the coming years.

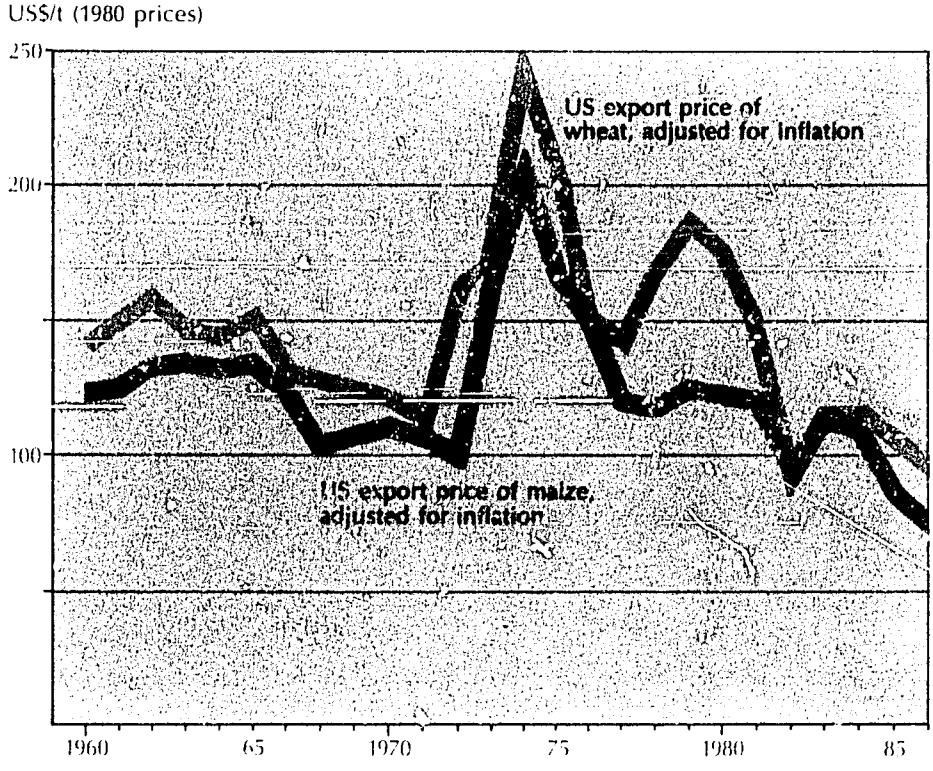

Figure 17. Long-term movements in US export prices of maize and wheat, adjusted for inflation, 1960 to 1986.

The signs now suggest that the world is in for a long period of adjustment to new policies in agriculture. During that period of adjustment, there will be downward pressure on prices as the huge grain stocks are reduced. So far, little fundamental change has taken place in US and EEC farmers' incentives for altering production. Until stronger measures are taken to ensure that incentives in developed country economies reflect the realities of the world market, there is a high probability that world prices will continue to be unstable and that smaller grain-exporting countries will face difficulties selling their grain in competition with subsidized US and EEC grain.

Agriculture will be an important subject of the multilateral trade negotiations that are to commence in 1987. The negotiations are unlikely to have much immediate impact, though, since they will probably be long and drawn out. Moreover, signficant changes in domestic policies would have to coincide with adjustments in trade policies before progress could be made in bringing farm policies out of their current disarray.

Many developing countries are faced with more stringent economic conditions in the 1980s than in the 1970s. A number of them are servicing massive debts and suffering major losses in economic growth as a result of the general decline in commodity prices. Those circumstances greatly diminish the prospects for growth in maize demand. Over the past three to four years, the major economies of the world have been emerging from the largest economic recession since the 1930s. Tight monetary policies have lowered inflation dramatically but at the price of reducing the fortunes of many Third World economies. Some developing countries might achieve strong growth (as Brazil did until mid-1986 under the Cruzado Plan), but most are expected to continue having difficulties.

Sizeable gains have been made in developing country maize yields, although the increases have not been as spectacular as those achieved in wheat and rice. Of the three crops, however, maize probably has the greatest potential for further advances in productivity, especially in tropical and subtropical environments.

In the meantime many people living in those environments are not in a position to take advantage of the bountiful harvests and huge grain reserves in other parts of the world. They live and farm in relative isolation and depend primarily on locally grown crops because they are too poor to buy imported food even at its currently low prices. The regions inhabited by those resource-poor farmers most urgently need investment in crop research and in agricultural development generally to help avert the interrelated catastrophes of hunger, malnutrition, and poverty and to promote overall economic advancement. In cooperation with national maize research programs and other organizations, CIMMYT will be making a special effort in the coming years to improve the productivity of resources committed to maize cultivation in regions where resource-poor farmers predominate.

Part 3: Selected Maize Statistics

The tables in this section each give 30 different statistics. Some of them relate to maize production, trade, utilization, and prices, while others are basic economic indicators. Among those statistics, we have also included a special set of data on maize seed and on the area planted to improved maize.

The information on seed and area of improved maize (variables 19 to 30 in the tables) were obtained from maize specialists in the countries for which data are reported. For the countries that did not provide data, we would be very grateful if interested maize specialists could send us information to make our data set more complete. Copies of the data (which are stored in computer on Lotus 1-2-3 spread sheet files) are available on request.

The developing countries listed in the tables are either maize producers or importers. The producers include countries that have grown approximately 100,000 t or more annually in recent years, and the importers are those that have brought more than 100,000 t into the country while producing less than that amount. Those distinctions were made on the basis of production and trade data for the years 1983-85.

The developed countries for which data are reported here are those producing more than 1 million tons of maize or importing at least that amount while producing less than 1 million tons. The regional aggregates given in the last table include *all* countries of the particular region.

Notes on the Variables

Variables 1-5: The source of this information was the *World Bank's World Development Report 1986*. The estimated population at mid-1985 was calculated by projecting the World Bank's mid-1984 estimates according to projected growth rates from 1980 to 2000.

Variables 6-13: The source of these data was the FAO's Tapes of Production Statistics, 1985. Revisions were made in the data when additional information from individual countries made it seem appropriate to do so. Growth rates were calculated using the standard formula for annual percentage compound growth:

$$x_t = x_0 [1 + (g/100)]^t$$

where x_t = average of data for ending period
x_0 = average of data for base period
t = number of years from the midpoint of one period to that of the other
g = average annual percent growth rate

Growth rates were not calculated for countries with maize areas of less than 20,000 ha.

Variables 14-18: The sources of these data were FAO's Tapes of Trade Statistics, 1984, and the USDA's Supply and Utilization Tables as of July 1986. Net imports are imports minus exports. Negative numbers indicate that the country is a net exporter. Utilization was calculated as production plus opening stocks plus imports minus closing stocks minus exports. Data on opening and closing stocks are from the USDA's Supply and Utilization Tables. Growth rates were calculated using the standard formula given above.

Variables 19-26: These data were collected through a general country survey that was conducted to supply background information for part 1 of this report. The area planted to improved maize is the area planted to F1 hybrids and seed of improved varieties that were released during the past 10 years. Commercial maize seed includes all seed sold by seed enterprises to farmers. All maize seed includes commercial seed and farmers' own seed (which includes that traded between farmers). For more details on those categorizations, see Longmire and Stewart.

Variables 27-30: These data (which are for 1985-86) were collected through a general country survey that was conducted to supply background information for part 1 of this report. The maize price is the postharvest price received by farmers. The price of nitrogen is that paid by farmers for the most common nitrogen fertilizer converted to nitrogen equivalents. The farm wage rate is the amount paid to unskilled laborers for one day of work.

		Angola	Burundi	Ethiopia	Kenya	Madagascar	Malawi	Mozambique
General indicators	1. Estimated population, 1985 (million)	10.2	4.7	43.3	20.4	10.2	7.0	13.8
	2. Estimated growth rate of population, 1980-2000 (% per year)	2.7	3.0	2.7	3.9	3.1	3.2	3.0
	3. Urban population as a percentage of total, 1985	24	7	15	16	22	12	13
	4. Per capita income, 1984 (US$)	. .	220	110	310	260	180	. .
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	. .	1.9	0.4	2.1	-1.6	1.7	. .
	6. Per capita cereal production, 1983-85 (kg per year)	40	95	123	126	235	240	43
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	-4.6	1.2	-1.2	-2.4	-1.0	0	-3.7
Maize production	8. Area harvested, 1983-85 (000 ha)	600	134	850	1547	140	1162	600
	9. Yield, 1983-85 (t/ha)	0.4	1.1	1.4	1.5	1.0	1.2	0.6
	10. Production, 1983-85 (000 t)	262	146	1182	2353	138	1397	333
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	0.7	1.4	0.4	1.6	1.5	1.5	1.8
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	-3.1	0.5	1.8	1.2	-0.7	0.9	-2.2
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	-2.4	1.8	2.2	2.9	0.8	2.5	-0.4
Maize imports	14. Net imports of maize, 1982-84 (000 t)	104	0	15	119	-1	-108	100
	15. Net imports per capita, 1961-65 (kg per year)	-23	0	0	2	0	-2	4
	16. Net imports per capita, 1982-84 (kg per year)	13	0	0	6	0	-17	8
	17. Per capita total maize utilization, 1982-84 (kg per year)	44	32	36	110	14	194	33
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	-1.6	0	0.4	-0.9	-2.0	-0.6	-2.6
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	. .	. .	. .	66	4	26	. .
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	. .	. .	. .	61	0	9	. .
	21. Total amount of commercial maize seed planted, 1985-86 (t)	. .	. .	. .	1800	100	5000	. .
	22. Total amount of all maize seed planted, 1985-86 (t)	. .	. .	. .	31,000	3800	30,000	. .
	23. Total value of maize seed purchased, 1985-86 (US$ million)	. .	. .	. .	9.0	0	3.3	. .
	24. Total value of all maize seed planted, 1985-86 (US$ million)	. .	. .	. .	11.1	0.9	7.5	. .
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	. .	. .	. .	4.5	. .	6.0	. .
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	. .	. .	. .	4.0	2.0	4.0	. .
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	. .	. .	. .	120	210	. .	. .
	28. Exchange rate, 1985-86 (local currency/US$)	. .	. .	. .	16.6	728	. .	. .
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	. .	. .	. .	8.7	2.6	. .	. .
	30. Farm wage in kg of maize per day, 1985-86	. .	. .	. .	3.5	5.0	. .	. .

nc Not calculated.
. . Missing data.

		Somalia	Tanzania	Uganda	Zambia	Zimbabwe	Regional total or average
General indicators	1. Estimated population, 1985 (million)	5.4	22.3	15.5	6.6	8.4	202
	2. Estimated growth rate of population, 1980-2000 (% per year)	3.0	3.5	3.3	3.4	3.4	3.0
	3. Urban population as a percentage of total, 1985	34	14	14	43	24	18
	4. Per capita income, 1984 (US$)	260	210	230	470	760	272
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	. .	0.6	2.9	-1.3	1.5	1.1
	6. Per capita cereal production, 1983-85 (kg per year)	86	150	77	142	243	129
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	-0.3	1.8	-2.3	-2.6	-0.6	-0.9
Maize production	8. Area harvested, 1983-85 (000 ha)	138	1483	358	512	1450	9252
	9. Yield, 1983-85 (t/ha)	0.9	1.1	1.0	1.7	1.2	1.2
	10. Production, 1983-85 (000 t)	130	1593	365	863	1693	10,782
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	0.8	2.4	2.9	-2.5	3.0	1.5
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	0.3	2.2	-0.3	3.4	0.4	1.1
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	1.1	4.6	2.5	0.8	3.4	2.6
Maize imports	14. Net imports of maize, 1982-84 (000 t)	98	157	7	109	-192	512
	15. Net imports per capita, 1961-65 (kg per year)	2	2	-1	-1	-36	-1
	16. Net imports per capita, 1982-84 (kg per year)	22	8	-1	18	-23	2
	17. Per capita total maize utilization, 1982-84 (kg per year)	52	85	26	149	138	58
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	0.6	1.2	-0.5	-1.8	-1.0	-0.4
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	. .	12	36	64	77	36
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	. .	5	1	53	60	25
	21. Total amount of commercial maize seed planted, 1985-86 (t)	. .	3400	600	7600	23,000	64,000
	22. Total amount of all maize seed planted, 1985-86 (t)	. .	43,000	10,000	13,500	31,000	235,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	. .	4.5	0.2	5.9	12.7	40
	24. Total value of all maize seed planted, 1985-86 (US$ million)	. .	19.7	2.3	6.7	13.7	77
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	. .	4.6	2.3	9.0	5.0	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	. .	3.5	1.3	7.3	1.9	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	. .	320	. .	. .	110	nc
	28. Exchange rate, 1985-86 (local currency/US$)	. .	18.0	. .	. .	1.6	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	. .	2.6	. .	. .	6.6	nc
	30. Farm wage in kg of maize per day, 1985-86	. .	5.4	. .	. .	17.8	nc

nc Not calculated.
. . Missing data.

		Benin	Cameroon	Ghana	Ivory Coast	Nigeria
General indicators	1. Estimated population, 1985 (million)	4.0	10.2	12.7	10.3	99.8
	2. Estimated growth rate of population, 1980-2000 (% per year)	3.2	3.3	3.5	3.7	3.4
	3. Urban population as a percentage of total, 1985	39	42	40	42	26
	4. Per capita income, 1984 (US$)	270	800	350	610	730
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	1.0	2.9	-1.9	0.2	2.8
	6. Per capita cereal production, 1983-85 (kg per year)	119	104	46	107	102
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	-0.1	-0.6	-1.0	0.2	-2.5
Maize production	8. Area harvested, 1983-85 (000 ha)	485	443	418	575	2022
	9. Yield, 1983-85 (t/ha)	0.8	1.2	1.0	0.8	1.0
	10. Production, 1983-85 (000 t)	370	510	402	478	2066
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	0.9	1.5	3.3	4.4	2.8
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	1.6	0.4	0	1.0	0.7
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	2.5	1.9	3.3	5.4	3.5
Maize imports	14. Net imports of maize, 1982-84 (000 t)	4	1	94	0	206
	15. Net imports per capita, 1961-65 (kg per year)	0	0	0	0	0
	16. Net imports per capita, 1982-84 (kg per year)	1	0	7	0	2
	17. Per capita total maize utilization, 1982-84 (kg per year)	83	54	35	48	22
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	-0.6	-0.4	1.2	1.2	-0.4
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	. .	30	30	10	40
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	. .	0	0	0	2
	21. Total amount of commercial maize seed planted, 1985-86 (t)	. .	100	1800	1000	4400
	22. Total amount of all maize seed planted, 1985-86 (t)	. .	13,000	9000	1800	59,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	. .	0.1	1.2	0.7	10.5
	24. Total value of all maize seed planted, 1985-86 (US$ million)	. .	2.5	5.9	3.0	42.8
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	. .	25.0	. . .	13.0	10.0
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	. .	3.3	2.7	6.0	4.0
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	. .	150	240	110	500
	28. Exchange rate, 1985-86 (local currency/US$)	. .	370	90.0	350	1.0
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	. .	10.0	1.3	6.3	0.9
	30. Farm wage in kg of maize per day, 1985-86	. .	12.0	4.5	17.5	10.0

nc Not calculated.
. . Missing data.

		Senegal	Togo	Burkina Faso	Zaire	Regional total or average
General indicators	1. Estimated population, 1985 (million)	6.6	3.0	6.7	30.7	227
	2. Estimated growth rate of population, 1980-2000 (% per year)	2.9	3.3	2.0	3.2	3.2
	3. Urban population as a percentage of total, 1985	42	20	8	34	30
	4. Per capita income, 1984 (US$)	380	250	160	140	509
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	-0.5	0.5	1.2	-1.6	-1.9
	6. Per capita cereal production, 1983-85 (kg per year)	132	132	166	37	96
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	-1.7	0	-0.4	1.6	-1.7
Maize production	8. Area harvested, 1983-85 (000 ha)	84	179	128	822	5630
	9. Yield, 1983-85 (t/ha)	1.2	1.1	0.7	0.9	0.9
	10. Production, 1983-85 (000 t)	101	191	90	709	5255
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	3.7	0.6	-1.0	2.4	2.0
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	1.9	3.9	0.6	1.2	0.6
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	5.7	4.6	-0.5	3.6	2.6
Maize imports	14. Net imports of maize, 1982-84 (000 t)	16	7	6	73	544
	15. Net imports per capita, 1961-65 (kg per year)	4	0	0	2	0
	16. Net imports per capita, 1982-84 (kg per year)	3	3	1	3	3
	17. Per capita total maize utilization, 1982-84 (kg per year)	15	64	14	27	26
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	0.5	1.5	-2.5	1.0	0
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	30	33	..	..	22
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	0	3	..	..	1
	21. Total amount of commercial maize seed planted, 1985-86 (t)	400	500	..	..	16,000
	22. Total amount of all maize seed planted, 1985-86 (t)	2000	4000	..	..	176,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	0.1	0.1	..	..	16
	24. Total value of all maize seed planted, 1985-86 (US$ million)	0.5	0.2	..	..	66
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	..	1.5	..	..	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	1.8	1.3	..	..	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	190	230	.	..	nc
	28. Exchange rate, 1985-86 (local currency/US$)	360	350	..	..	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	2.5	5.0	..	..	nc
	30. Farm wage in kg of maize per day, 1985-86	3.2	5.6	..	..	nc

nc Not calculated.
.. Missing data.

		Egypt	Morocco	Algeria	Tunisia	Regional total or average
General indicators	1. Estimated population, 1985 (million)	46.9	21.9	21.9	7.2	102
	2. Estimated growth rate of population, 1980-2000 (% per year)	2.2	2.4	3.3	2.3	2.6
	3. Urban population as a percentage of total, 1985	44	42	52	52	47
	4. Per capita income, 1984 (US$)	720	670	2410	1270	1385
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	4.3	2.8	3.6	4.4	2.9
	6. Per capita cereal production, 1983-85 (kg per year)	186	190	99	199	166
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	-0.7	-1.3	-2.2	-0.2	-1.1
Maize production	8. Area harvested, 1983-85 (000 ha)	805	405	2	. .	1213
	9. Yield, 1983-85 (t/ha)	4.4	0.7	1.0	. .	3.2
	10. Production, 1983-85 (000 t)	3554	267	2	. .	3824
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	0.8	-0.4	. .	. .	0.4
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	2.2	-0.9	. .	. .	2.1
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	3.0	-1.3	. .	. .	2.5
Maize imports	14. Net imports of maize, 1982-84 (000 t)	1425	152	399	280	2340
	15. Net imports per capita, 1961-65 (kg per year)	8	-4	0	1	3
	16. Net imports per capita, 1982-84 (kg per year)	32	7	20	41	24
	17. Per capita total maize utilization, 1982-84 (kg per year)	113	20	20	46	65
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	2.0	-1.0	19.8	18.8	2.2
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	64	. .	. .	. .	49
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	10	. .	. .	. .	7
	21. Total amount of commercial maize seed planted, 1985-86 (t)	9300	. .	. .	. .	11,000
	22. Total amount of all maize seed planted, 1985-86 (t)	25,000	. .	. .	. .	36,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	2.1	. .	. .	. .	2
	24. Total value of all maize seed planted, 1985-86 (US$ million)	5.3	. .	. .	. .	7
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	1.4	. .	. .	. .	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	. .	. .	. .	. .	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	190	. .	. .	. .	nc
	28. Exchange rate, 1985-86 (local currency/US$)	1.4	. .	. .	. .	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	1.4	. .	. .	. .	nc
	30. Farm wage in kg of maize per day, 1985-86	16.0	. .	. .	. .	nc

nc Not calculated.
. . Missing data.

		Afganistan	Turkey	Iran	Iraq	Jordan	Lebanon	Saudi Arabia	Syria	Regional total or average
General indicators	1. Estimated population, 1985 (million)	14.2	49.4	45.2	15.6	3.5	2.7	11.5	10.5	169
	2. Estimated growth rate of population, 1980-2000 (% per year)	1.0	2.0	3.1	3.5	4.0	0.5	3.7	3.5	2.9
	3. Urban population as a percentage of total, 1985	16	45	50	68	60	76	70	47	49
	4. Per capita income, 1984 (US$)	..	1160	550	..	1570	..	10,530	..	3129
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	..	2.9	5.9	..	4.8	..	5.9	..	5.6
	6. Per capita cereal production, 1983-85 (kg per year)	276	534	207	96	34	9	130	229	275
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	-0.7	0.3	0.1	-4.4	-6.5	-7.4	2.0	-2.1	-0.6
Maize production	8. Area harvested, 1983-85 (000 ha)	471	560	45	17	0	0	2	29	1159
	9. Yield, 1983-85 (t/ha)	1.7	2.9	1.4	1.8	0	0	2.0	1.7	2.3
	10. Production, 1983-85 (000 t)	802	1627	63	30	0	0	4	50	2632
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	-0.3	-0.9	3.2	10.4	..	..	..	7.0	-0.2
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	0.9	3.5	0.7	2.1	..	..	..	2.4	2.3
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	0.6	2.6	3.9	12.7	..	..	..	9.7	2.0
Maize imports	14. Net imports of maize, 1982-84 (000 t)	0	52	757	202	137	131	812	235	2516
	15. Net imports per capita, 1961-65 (kg per year)	0	0	0	0	3	13	6	1	1
	16. Net imports per capita, 1982-84 (kg per year)	0	1	18	14	42	50	76	24	16
	17. Per capita total maize utilization, 1982-84 (kg per year)	49	31	19	16	43	52	76	29	31
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	-1.2	-0.3	13.6	21.3	14.0	5.3	13.4	9.7	2.3
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	..	46	..	..	..	..	..	100	44
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	..	33	..	..	..	..	..	88	23
	21. Total amount of commercial maize seed planted, 1985-86 (t)	..	7200	..	..	..	..	..	1500	11,000
	22. Total amount of all maize seed planted, 1985-86 (t)	..	18,300	..	..	..	..	..	2000	35,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	..	8.1	..	..	..	..	..	2.4	12
	24. Total value of all maize seed planted, 1985-86 (US$ million)	..	9.8	..	..	..	..	..	2.4	16
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	..	11.4	..	..	..	..	..	3.6	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	..	5.7	..	..	..	..	..	1.8	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	..	110	..	..	..	..	..	470	nc
	28. Exchange rate, 1985-86 (local currency/US$)	..	650	..	..	..	..	..	3.9	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	..	..	..	..	..	..	..	1.2	nc
	30. Farm wage in kg of maize per day, 1985-86	..	..	..	..	..	..	..	13.7	nc

nc Not calculated.
.. Missing data.

		Burma	India	Nepal	Pakistan	Regional total or average
General indicators	1. Estimated population, 1985 (million)	36.8	763	16.5	94.8	1030
	2. Estimated growth rate of population, 1980-2000 (% per year)	2.1	1.9	2.6	2.6	2.0
	3. Urban population as a percentage of total, 1985	24	23	6	29	23
	4. Per capita income, 1984 (US$)	180	260	160	380	256
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	2.3	1.6	0.2	2.5	1.7
	6. Per capita cereal production, 1983-85 (kg per year)	422	222	226	186	227
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	1.0	0.9	-0.9	1.6	0.7
Maize production	8. Area harvested, 1983-85 (000 ha)	185	5896	520	801	7493
	9. Yield, 1983-85 (t/ha)	1.7	1.3	1.5	1.3	1.3
	10. Production, 1983-85 (000 t)	317	7759	784	1024	10,005
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	3.7	1.2	0.8	2.3	1.3
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	4.6	1.4	-1.2	1.0	1.1
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	8.5	2.5	-0.4	3.3	2.4
Maize imports	14. Net imports of maize, 1982-84 (000 t)	-26	0	0	0	-24
	15. Net imports per capita, 1961-65 (kg per year)	-1	0	0	0	0
	16. Net imports per capita, 1982-84 (kg per year)	-1	0	0	0	0
	17. Per capita total maize utilization, 1982-84 (kg per year)	6	10	49	11	10
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	6.7	0.3	-2.8	0.6	0
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	34	36	. .	28	34
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	0	13	. .	2	11
	21. Total amount of commercial maize seed planted, 1985-86 (t)	2100	22,000	. .	2800	29,000
	22. Total amount of all maize seed planted, 1985-86 (t)	7000	110,200	. .	32,000	166,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	0.3	9.7	. .	0.7	12
	24. Total value of all maize seed planted, 1985-86 (US$ million)	1.0	30.9	. .	4.8	40
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	6.0	3.8	. .	3.3	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	1.0	3.4	. .	1.3	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	. .	120	. .	150	nc
	28. Exchange rate, 1985-86 (local currency/US$)	. .	12.5	. .	16.2	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	. .	3.2	. .	2.8	nc
	30. Farm wage in kg of maize per day, 1985-86	. .	6.3	. .	10.0	nc

nc Not calculated.
. . Missing data.

		Indonesia	Philippines	Thailand	Vietnam
General indicators	1. Estimated population, 1985 (million)	161.9	54.6	51.7	61.6
	2. Estimated growth rate of population, 1980-2000 (% per year)	1.9	2.2	1.7	2.5
	3. Urban population as a percentage of total, 1985	22	37	17	19
	4. Per capita income, 1984 (US$)	540	660	. .	. .
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	4.9	2.6	. .	. .
	6. Per capita cereal production, 1983-85 (kg per year)	261	216	480	270
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	2.7	1.1	0.7	0
Maize production	8. Area harvested, 1983-85 (000 ha)	2615	3361	1709	387
	9. Yield, 1983-85 (t/ha)	2.0	1.0	2.4	1.3
	10. Production, 1983-85 (000 t)	5225	3361	4154	499
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	-0.4	2.6	6.9	1.9
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	3.5	2.0	1.1	0.5
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	3.0	4.6	8.1	2.4
Maize imports	14. Net imports of maize, 1982-84 (000 t)	-5	351	-2848	-42
	15. Net imports per capita, 1961-65 (kg per year)	0	0	-25	1
	16. Net imports per capita, 1982-84 (kg per year)	0	7	-58	-1
	17. Per capita total maize utilization, 1982-84 (kg per year)	28	69	15	8
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	0.1	2.5	6.3	-1.2
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	25	26	70	38
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	1	1	8	0
	21. Total amount of commercial maize seed planted, 1985-86 (t)	3100	12,100	25,600	1500
	22. Total amount of all maize seed planted, 1985-86 (t)	117,000	82,000	48,000	10,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	2.6	8.4	15.5	0.8
	24. Total value of all maize seed planted, 1985-86 (US$ million)	53.0	19.9	17.7	2.2
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	14.0	14.3	18.2	. .
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	6.0	4.3	5.7	. .
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	110	140	80	. .
	28. Exchange rate, 1985-86 (local currency/US$)	1125	20.5	26.0	. .
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	2.2	2.8	8.7	. .
	30. Farm wage in kg of maize per day, 1985-86	18.0	12.5	20.8	. .

nc Not calculated.
. . Missing data.

		Hong Kong	Malaysia	Singapore	Regional total or average
General indicators	1. Estimated population, 1985 (million)	5.5	15.6	2.6	371
	2. Estimated growth rate of population, 1980-2000 (% per year)	1.2	2.1	1.0	2.0
	3. Urban population as a percentage of total, 1985	..	32	100	25
	4. Per capita income, 1984 (US$)	6330	1980	7260	853
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	6.2	4.5	7.8	4.6
	6. Per capita cereal production, 1983-85 (kg per year)	0	122	0	271
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	-30.0	-0.3	0	1.3
Maize production	8. Area harvested, 1983-85 (000 ha)	..	14	..	8158
	9. Yield, 1983-85 (t/ha)	..	1.6	..	1.6
	10. Production, 1983-85 (000 t)	..	22	..	13,405
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	..	..	..	1.7
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	..	..	..	2.6
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	..	..	..	4.4
Maize imports	14. Net imports of maize, 1982-84 (000 t)	272	804	365	-1075
	15. Net imports per capita, 1961-65 (kg per year)	23	9	0	-2
	16. Net imports per capita, 1982-84 (kg per year)	51	54	146	-3
	17. Per capita total maize utilization, 1982-84 (kg per year)	51	55	146	30
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	-4.1	-9.0	14.0	1.7
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	..	..	..	37
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	..	..	..	3
	21. Total amount of commercial maize seed planted, 1985-86 (t)	..	..	..	43,000
	22. Total amount of all maize seed planted, 1985-86 (t)	..	..	..	258,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	..	..	..	27
	24. Total value of all maize seed planted, 1985-86 (US$ million)	..	..	..	93
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	..	..	..	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	..	..	..	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	..	..	..	nc
	28. Exchange rate, 1985-86 (local currency/US$)	..	..	..	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	..	..	..	nc
	30. Farm wage in kg of maize per day, 1985-86	..	..	..	nc

nc Not calculated.
.. Missing data.

		China	North Korea	Taiwan	South Korea	Regional total or average
General indicators	1. Estimated population, 1985 (million)	1042	20.6	19.2	43.3	1127
	2. Estimated growth rate of population, 1980-2000 (% per year)	1.2	3.7	. .	1.4	1.2
	3. Urban population as a percentage of total, 1985	21	64	71	57	24
	4. Per capita income, 1984 (US$)	310	. .	. .	2110	382
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	4.5	. .	. .	6.6	4.9
	6. Per capita cereal production, 1983-85 (kg per year)	338	510	175	215	334
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	2.7	1.7	-1.7	-0.3	2.5
Maize production	8. Area harvested, 1983-85 (000 ha)	18,403	423	52	28	18,905
	9. Yield, 1983-85 (t/ha)	3.7	6.1	3.4	4.4	3.7
	10. Production, 1983-85 (000 t)	67,873	2593	178	122	70,766
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	1.0	2.6	5.1	-1.0	1.1
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	4.8	1.5	2.7	8.8	4.7
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	5.8	4.1	7.9	7.7	5.8
Maize imports	14. Net imports of maize, 1982-84 (000 t)	1025	0	2988	3325	7338
	15. Net imports per capita, 1961-65 (kg per year)	0	1	1	1	1
	16. Net imports per capita, 1982-84 (kg per year)	1	0	161	83	7
	17. Per capita total maize utilization, 1982-84 (kg per year)	67	128	170	86	71
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	4.0	1.4	21.0	23.0	4.4
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	72	. .	96	. .	72
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	72	. .	92	. .	71
	21. Total amount of commercial maize seed planted, 1985-86 (t)	389,100	. .	1400	. .	397,000
	22. Total amount of all maize seed planted, 1985-86 (t)	567,000	. .	1500	. .	581,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	146	. .	.1	. .	152
	24. Total value of all maize seed planted, 1985-86 (US$ million)	159	. .	1.1	. .	166
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	. .	. .	. .	. .	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	. .	. .	. .	. .	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	310	. .	250	. .	nc
	28. Exchange rate, 1985-86 (local currency/US$)	3.2	. .	38.8	. .	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	2.8	. .	1.3	. .	nc
	30. Farm wage in kg of maize per day, 1985-86	4.8	. .	31.3	. .	nc

nc Not calculated.
. . Missing data.

		Costa Rica	Cuba	El Salvador	Guatemala	Haiti	Honduras
General indicators	1. Estimated population, 1985 (million)	2.6	10.0	5.5	7.9	5.5	4.3
	2. Estimated growth rate of population, 1980-2000 (% per year)	2.1	1.0	2.7	2.6	1.8	3.0
	3. Urban population as a percentage of total, 1985	48	70	39	39	28	37
	4. Per capita income, 1984 (US$)	1190	. .	710	1160	320	700
	5 Growth rate of real per capita income, 1965 to 1984 (% per year)	1.6	. .	-0.6	2.0	1.0	0.5
	6. Per capita cereal production, 1983-85 (kg per year)	153	63	128	160	58	147
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	2.0	2.8	0.6	0.2	1.3	-0.6
Maize production	8. Area harvested, 1983-85 (000 ha)	62	77	242	777	157	353
	9. Yield, 1983-85 (t/ha)	1.7	1.3	2.1	1.4	0.9	1.5
	10. Production, 1983-85 (000 t)	105	97	497	1067	147	520
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	0.5	-1.2	1.3	0.7	-1.6	1.2
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	2.0	1.4	3.1	2.1	-0.5	1.5
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	2.6	0.2	4.5	2.8	-2.1	2.7
Maize imports	14. Net imports of maize, 1982-84 (000 t)	52	398	66	5	8	8
	15. Net imports per capita, 1961-65 (kg per year)	3	3	11	3	0	-17
	16. Net imports per capita, 1982-84 (kg per year)	21	40	13	1	1	2
	17. Per capita total maize utilization, 1982-84 (kg per year)	55	50	97	139	29	118
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	2.0	2.7	1.0	0	-3.4	-0
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	20	. .	71	60	1	. .
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	6	. .	71	36	0	. .
	21. Total amount of commercial maize seed planted, 1985-86 (t)	200	. .	3600	8600	0	. .
	22. Total amount of all maize seed planted, 1985-86 (t)	2000	. .	5000	16,000	8000	. .
	23. Total value of maize seed purchased, 1985-86 (US$ million)	0.3	. .	1.6	3.9	0.1	. .
	24. Total value of all maize seed planted, 1985-86 (US$ million)	0.6	. .	1.7	5.2	3.3	. .
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	7.8	. .	3.6	3.7	11.4	. .
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	3.7	. .	3.0	2.9	7.9	. .
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	220	. .	120	140	240	. .
	28. Exchange rate, 1985-86 (local currency/US$)	53.5	. .	5	2.5	5	. .
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	3.1	. .	6.4	3.0	4.4	. .
	30. Farm wage in kg of maize per day, 1985-86	3.2	. .	17.8	14.0	2.5	. .

nc Not calculated.
. . Missing data.

		Mexico	Nicaragua	Dominican Republic	Jamaica	Regional total or average
General indicators	1. Estimated population, 1985 (million)	78.6	3.3	6.2	2.2	135
	2. Estimated growth rate of population, 1980-2000 (% per year)	2.3	2.9	2.2	1.2	2.2
	3. Urban population as a percentage of total, 1985	70	53	2	1	61
	4. Per capita income, 1984 (US$)	2040	860	970	1150	1714
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	2.9	-1.5	3.2	-0.4	2.5
	6. Per capita cereal production, 1983-85 (kg per year)	325	162	97	4	233
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	1.3	0.4	3.0	-1.0	1.3
Maize production	8. Area harvested, 1983-85 (000 ha)	8234	172	40	3	10,204
	9. Yield, 1983-85 (t/ha)	1.7	1.2	1.6	1.7	1.6
	10. Production, 1983-85 (000 t)	13,765	213	62	5	16,567
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	0.8	0	1.3	-2.8	0.7
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	2.2	1.7	0.2	3.1	2.1
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	3.0	1.7	1.6	0.3	2.9
Maize imports	14. Net imports of maize, 1982-84 (000 t)	2464	59	206	173	3623
	15. Net imports per capita, 1961-65 (kg per year)	-5	3	-2	11	0
	16. Net imports per capita, 1982-84 (kg per year)	33	19	35	76	21
	17. Per capita total maize utilization, 1982-84 (kg per year)	200	82	43	79	56
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	0.8	-0.8	7.0	9.2	1.4
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	42	17	. .	. .	42
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	25	9	. .	. .	26
	21. Total amount of commercial maize seed planted, 1985-86 (t)	69,000	900	. .	. .	86,000
	22. Total amount of all maize seed planted, 1985-86 (t)	211,400	6000	. .	. .	261,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	18.9	0.6	. .	. .	28
	24. Total value of all maize seed planted, 1985-86 (US$ million)	39.5	1.4	. .	. .	56
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	6.0	. .	. .	. .	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	2.4	. .	. .	. .	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	100	50	. .	. .	nc
	28. Exchange rate, 1985-86 (local currency/US$)	520	975	. .	. .	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	1.5	. .	. .	. .	nc
	30. Farm wage in kg of maize per day, 1985-86	25.1	. .	. .	. .	nc

nc Not calculated.
. . Missing data.

		Bolivia	Colombia	Ecuador	Peru	Venezuela	Regional total or average
General indicators	1. Estimated population, 1985 (million)	6.3	28.9	9.3	18.6	17.2	82
	2. Estimated growth rate of population, 1980-2000 (% per year)	2.4	1.8	2.3	2.2	2.6	2.2
	3. Urban population as a percentage of total, 1985	46	67	45	65	76	64
	4. Per capita income, 1984 (US$)	540	1390	1150	1000	3410	1623
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	0.2	3.0	3.8	-0.1	0.9	1.7
	6. Per capita cereal production, 1983-85 (kg per year)	122	116	71	98	93	108
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	0.3	0.9	-2.2	-0.5	1.2	0.2
Maize production	8. Area harvested, 1983-85 (000 ha)	311	592	185	304	368	1761
	9. Yield, 1983-85 (t/ha)	1.5	1.5	1.4	2.3	1.8	1.7
	10. Production, 1983-85 (000 t)	460	870	257	689	645	2923
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	1.8	-1.1	-1.6	-0.5	-0.9	-0.6
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	1.1	1.4	3.9	2.1	2.3	2.0
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	2.9	0.2	2.3	1.6	1.4	1.3
Maize imports	14. Net imports of maize, 1982-84 (000 t)	-5	53	8	320	1250	1651
	15. Net imports per capita, 1961-65 (kg per year)	0	1	0	1	6	2
	16. Net imports per capita, 1982-84 (kg per year)	-1	2	1	17	76	21
	17. Per capita total maize utilization, 1982-84 (kg per year)	72	35	34	53	111	56
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	2.9	-1.6	0	0.7	2.8	0.7
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	..	15	32	50	43	29
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	..	13	3	43	30	20
	21. Total amount of commercial maize seed planted, 1985-86 (t)	..	2400	1300	5000	3900	13,000
	22. Total amount of all maize seed planted, 1985-86 (t)	..	17,000	5000	12,000	14,000	56,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	..	2.9	0.6	4.8	3.0	12
	24. Total value of all maize seed planted, 1985-86 (US$ million)	..	6.9	1.5	7.1	3.0	34
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	..	..	3.9	4.2	4.7	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	..	..	2.3	2.1	3.3	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	..	..	190	240	170	nc
	28. Exchange rate, 1985-86 (local currency/US$)	..	..	145	14.0	18.0	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	..	..	1.9	1.6	0.6	nc
	30. Farm wage in kg of maize per day, 1985-86	..	..	11.9	7.6	20.0	nc

nc Not calculated.
.. Missing data.

		Argentina	Brazil	Chile	Paraguay	Uruguay	Regional total or average
General indicators	1. Estimated population, 1985 (million)	30.5	135.3	12.0	3.4	3.0	182
	2. Estimated growth rate of population, 1980-2000 (% per year)	1.3	2.0	1.4	2.3	0.7	1.8
	3. Urban population as a percentage of total, 1985	83	68	83	39	64	71
	4. Per capita income, 1984 (US$)	2230	1720	1700	1240	1980	1796
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	0.3	4.6	-0.1	4.4	1.8	2.8
	6. Per capita cereal production, 1983-85 (kg per year)	1013	246	166	184	389	369
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	1.5	0.7	-0.6	3.2	1.3	0.8
Maize production	8. Area harvested, 1983-85 (000 ha)	3096	11,583	129	390	97	15,295
	9. Yield, 1983-85 (t/ha)	3.3	1.8	5.2	1.2	1.1	2.1
	10. Production, 1983-85 (000 t)	10,367	20,638	668	473	107	32,254
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	0.4	1.9	2.0	5.7	-4.0	1.5
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	3.1	1.5	3.8	-0.2	2.6	1.9
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	3.5	3.5	5.8	5.5	-1.5	3.5
Maize imports	14. Net imports of maize, 1982-84 (000 t)	-5757	-339	192	-2	4	-5902
	15. Net imports per capita, 1961-65 (kg per year)	-123	-3	1	-4	6	-26
	16. Net imports per capita, 1982-84 (kg per year)	-194	-3	17	-1	1	-33
	17. Per capita total maize utilization, 1982-84 (kg per year)	123	157	66	137	40	143
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	1.5	0.7	4.8	3.0	-2.2	1.3
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	100	70	81	. .	. .	76
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	100	63	68	. .	. .	70
	21. Total amount of commercial maize seed planted, 1985-86 (t)	66,000	156,000	2600	. .	. .	232,000
	22. Total amount of all maize seed planted, 1985-86 (t)	66,000	248,000	4000	. .	. .	329,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	82.3	123	4.9	. .	. .	215
	24. Total value of all maize seed planted, 1985-86 (US$ million)	82.3	133	5.0	. .	. .	226
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	21.2	9.2	19.0	. .	. .	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	. .	6.7	10.0	. .	. .	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	60	90	100	. .	. .	nc
	28. Exchange rate, 1985-86 (local currency/US$)	0.9	13.7	193	. .	. .	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	7.6	4.3	4.8	. .	. .	nc
	30. Farm wage in kg of maize per day, 1985-86	68.4	41.7	20.0	. .	. .	nc

nc Not calculated.
. . Missing data.

		Bulgaria	Czecho-slovakia	Hungary	Romania	USSR
General indicators	1. Estimated population, 1985 (million)	9.0	15.5	10.7	22.8	277
	2. Estimated growth rate of population, 1980-2000 (% per year)	0.2	0.3	-0.1	0.6	0.7
	3. Urban population as a percentage of total, 1985	65	74	54	49	64
	4. Per capita income, 1984 (US$)	. .	. .	. .	. .	. .
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	. .	. .	. .	. .	. .
	6. Per capita cereal production, 1983-85 (kg per year)	904	751	1384	976	642
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	2.0	3.0	3.5	2.5	0.8
Maize production	8. Area harvested, 1983-85 (000 ha)	549	187	1113	2962	4098
	9. Yield, 1983-85 (t/ha)	5.3	5.0	6.0	4.4	3.3
	10. Production, 1983-85 (000 t)	2903	925	6637	13,019	13,667
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	-0.7	0.2	-0.7	-0.5	-1.7
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	3.6	3.0	4.0	4.4	1.9
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	2.9	3.2	3.3	3.9	0.2
Maize imports	14. Net imports of maize, 1982-84 (000 t)	186	645	-293	392	9677
	15. Net imports per capita, 1961-65 (kg per year)	-5	18	13	-46	-3
	16. Net imports per capita, 1982-84 (kg per year)	21	42	-28	-17	36
	17. Per capita total maize utilization, 1982-84 (kg per year)	376	98	630	541	82
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	3.4	3.2	3.5	3.6	2.0
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	100	. .	100	. .	. .
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	100	. .	100	. .	. .
	21. Total amount of commercial maize seed planted, 1985-86 (t)	11,000	. .	33,000	. .	. .
	22. Total amount of all maize seed planted, 1985-86 (t)	11,000	. .	33,000	. .	. .
	23. Total value of maize seed purchased, 1985-86 (US$ million)	18.3	. .	38.4	. .	. .
	24. Total value of all maize seed planted, 1985-86 (US$ million)	18.3	. .	38.4	. .	. .
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	. .	. .	14.8	. .	. .
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	4.0	. .	. .	. .	. .
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	130	. .	80	. .	. .
	28. Exchange rate, 1985-86 (local currency/US$)	0.9	. .	45.1	. .	. .
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	. .	. .	3.7	. .	. .
	30. Farm wage in kg of maize per day, 1985-86	. .	. .	56.2	. .	. .

nc Not calculated.
. . Missing data.

		Yugoslavia	East Germany	Poland	Regional total or average
General indicators	1. Estimated population, 1985 (million)	23.1	16.7	37.2	415
	2. Estimated growth rate of population, 1980-2000 (% per year)	0.6	0	0.7	0.6
	3. Urban population as a percentage of total, 1985	46	77	59	62
	4. Per capita income, 1984 (US$)	. .	. .	. .	. .
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	. .	. .	. .	. .
	6. Per capita cereal production, 1983-85 (kg per year)	743	659	635	693
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	1.5	6.0	2.3	1.3
Maize production	8. Area harvested, 1983-85 (000 ha)	2542	3	15	11,360
	9. Yield, 1983-85 (t/ha)	4.2	0.3	4.2	4.2
	10. Production, 1983-85 (000 t)	10,641	1	63	48,245
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	-0.3	. .	. .	-1.1
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	3.4	. .	. .	3.2
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	3.1	. .	. .	2.0
Maize imports	14. Net imports of maize, 1982-84 (000 t)	-613	881	457	10,538
	15. Net imports per capita, 1961-65 (kg per year)	-4	16	9	0
	16. Net imports per capita, 1982-84 (kg per year)	-27	53	13	26
	17. Per capita total maize utilization, 1982-84 (kg per year)	447	52	13	142
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	2.2	6.2	2.6	2.6
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	75	. .	100	95
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	75	. .	100	95
	21. Total amount of commercial maize seed planted, 1985-86 (t)	0	. .	14,000	222,000
	22. Total amount of all maize seed planted, 1985-86 (t)	36,000	. .	14,000	234,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	66.6	. .	8.3	345
	24. Total value of all maize seed planted, 1985-86 (US$ million)	68.4	. .	8.3	347
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	15.0	. .	3.3	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	..	. .	0	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	120	. .	180	nc
	28. Exchange rate, 1985-86 (local currency/US$)	342	. .	166	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	3.9	. .	1.2	2.5
	30. Farm wage in kg of maize per day, 1985-86	35.5	. .	16.7	31

nc Not calculated.
. . Missing data.

		Austria	Canada	France	West Germany	Greece	Italy	Spain	South Africa
General indicators	1. Estimated population, 1985 (million)	7.6	25.3	55.2	61.1	9.9	57.1	39.0	32.4
	2. Estimated growth rate of population, 1980-2000 (% per year)	0.1	0.9	0.5	-0.1	0.4	0.2	0.7	2.5
	3. Urban population as a percentage of total, 1985	72	74	73	94	70	72	91	56
	4. Per capita income, 1984 (US$)	6420	13,280	9760	11,130	3770	6420	4440	2340
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	2.7	2.4	3.0	2.7	3.8	2.7	2.7	0.3
	6. Per capita cereal production, 1983-85 (kg per year)	706	1846	970	411	501	328	486	250
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	4.0	1.0	2.9	2.3	2.5	0.9	2.7	-1.4
Maize production	8. Area harvested, 1983-85 (000 ha)	207	1154	1755	177	194	953	438	4139
	9. Yield, 1983-85 (t/ha)	7.6	5.9	6.2	6.0	9.7	6.9	5.8	1.3
	10. Production, 1983-85 (000 t)	1574	6783	10,952	1055	1885	6609	2547	5340
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	6.9	8.1	3.2	12.2	0.7	-0.7	-0.3	-0.1
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	3.3	1.0	3.5	2.6	9.5	3.6	4.4	0.2
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	10.4	9.2	6.8	15.1	10.3	2.9	4.1	0.1
Maize imports	14. Net imports of maize, 1982-84 (000 t)	-40	-28	-3614	1586	295	1419	4194	-429
	15. Net imports per capita, 1961-65 (kg per year)	52	32	-1	26	13	62	27	-76
	16. Net imports per capita, 1982-84 (kg per year)	-5	-1	-66	26	30	25	110	-14
	17. Per capita total maize utilization, 1982-84 (kg per year)	198	256	127	43	222	144	174	214
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	4.7	5.5	2.9	2.5	9.0	1.0	5.3	0.4
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	. .	100	100	100	100	100	100	97
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	. .	100	100	100	100	100	100	95
	21. Total amount of commercial maize seed planted, 1985-86 (t)	. .	24,000	58,000	37,000	5000	16,000	9000	80,000
	22. Total amount of all maize seed planted, 1985-86 (t)	. .	24,000	58,000	37,000	5000	16,000	9000	85,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	. .	59.2	187	118	16.7	53.2	30	74.5
	24. Total value of all maize seed planted, 1985-86 (US$ million)	. .	59.2	187	118	16.7	53.2	30.4	75.1
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	. .	30.9	25.0	15.6	25.0	25.0	25.0	8.3
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	. .	. .	4.0	8.9	. .	4.0	4.0	2.4
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	. .	80	130	200	140	. .	. .	110
	28. Exchange rate, 1985-86 (local currency/US$)	. .	1.4	7.4	2.2	145	. .	. .	2
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	. .	4.9	2.7	3.6	1.9	. .	. .	5.1
	30. Farm wage in kg of maize per day, 1985-86	. .	455	280	178	100	. .	. .	13.0

nc Not calculated.
. . Missing data.

		USA	Belgium/ Luxem-burg	Japan	Nether-lands	Portu-gal	United King-dom	Regional total or average
General indicators	1. Estimated population, 1985 (million)	239	9.9	121	14.5	10.3	56.5	794
	2. Estimated growth rate of population, 1980-2000 (% per year)	0.7	0.1	0.5	0.7	0.6	0.1	0.6
	3. Urban population as a percentage of total, 1985	76	86	76	88	30	76	75
	4. Per capita income, 1984 (US$)	15,390	8610	10,630	9520	1970	8570	10,560
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	1.7	3.0	4.7	2.1	3.5	1.6	2.4
	6. Per capita cereal production, 1983-85 (kg per year)	1225	217	128	89	138	413	716
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	1.5	0.3	-2.1	-3.0	-1.2	3.0	1.7
Maize production	8. Area harvested, 1983-85 (000 ha)	26,767	9	1	. .	356	. .	36,275
	9. Yield, 1983-85 (t/ha)	6.6	7.1	1.0	. .	1.5	. .	5.8
	10. Production, 1983-85 (000 t)	175,383	64	1	. .	519	. .	213,284
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	0.7	. .	. .	. .	-1.5	. .	0.7
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	2.2	. .	. .	. .	1.2	. .	2.4
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	2.9	. .	. .	. .	-0.4	. .	3.2
Maize imports	14. Net imports of maize, 1982-84 (000 t)	-48,526	1427	14,147	2102	2249	1796	-22,348
	15. Net imports per capita, 1961-65 (kg per year)	-60	64	28	137	9	67	5
	16. Net imports per capita, 1982-84 (kg per year)	-207	140	119	146	223	32	-28
	17. Per capita total maize utilization, 1982-84 (kg per year)	550	145	118	147	270	32	247
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	0.7	4.0	7.4	0.4	7.0	-3.6	1.7
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	100	. .	. .	. .	18	. .	99
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	100	. .	. .	. .	16	. .	99
	21. Total amount of commercial maize seed planted, 1985-86 (t)	551,000	. .	. .	. .	1000	. .	790,000
	22. Total amount of all maize seed planted, 1985-86 (t)	551,000	. .	. .	. .	12,000	. .	805,000
	23. Total value of maize seed purchased, 1985-86 (US$ million)	1460	. .	. .	. .	4.7	. .	2027
	24. Total value of all maize seed planted, 1985-86 (US$ million)	1460	. .	. .	. .	7.6	. .	2031
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	20.4	. .	. .	. .	12.5	. .	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	. .	. .	. .	. .	. .	. .	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	90	. .	. .	. .	270	. .	nc
	28. Exchange rate, 1985-86 (local currency/US$)	1	. .	. .	. .	150	. .	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	4.6	. .	. .	. .	2.3	. .	nc
	30. Farm wage in kg of maize per day, 1985-86	622	. .	. .	. .	32.5	. .	nc

nc Not calculated.
. . Missing data.

		Developing countries	Developed market economies	Eastern Europe and USSR	World
General indicators	1. Estimated population, 1985 (million)	3630	794	415	4840
	2. Estimated growth rate of population, 1980-2000 (% per year)	2.0	0.6	0.6	1.7
	3. Urban population as a percentage of total, 1985	30	75	62	40
	4. Per capita income, 1984 (US$)	640	10,560	. .	2650
	5. Growth rate of real per capita income, 1965 to 1984 (% per year)	3.0	2.4	. .	1.5
	6. Per capita cereal production, 1983-85 (kg per year)	257	716	693	371
	7. Growth rate of per capita cereal production, 1961-65 to 1983-85 (% per year)	1.2	1.7	1.3	1.0
Maize production	8. Area harvested, 1983-85 (000 ha)	79,071	36,275	11,360	126,706
	9. Yield, 1983-85 (t/ha)	2.1	5.9	4.2	3.4
	10. Production, 1983-85 (000 t)	168,408	213,284	48,245	429,937
	11. Growth rate of area, 1961-65 to 1983-85 (% per year)	1.2	0.7	-1.1	0.9
	12. Growth rate of yield, 1961-65 to 1983-85 (% per year)	2.8	2.4	3.2	2.5
	13. Growth rate of production, 1961-65 to 1983-85 (% per year)	4.0	3.2	2.0	3.4
Maize imports	14. Net imports of maize, 1982-84 (000 t)	11,494	-22,348	10,538	-317
	15. Net imports per capita, 1961-65 (kg per year)	-1	5	0	6[a]
	16. Net imports per capita, 1982-84 (kg per year)	3	-28	26	15[a]
	17. Per capita total maize utilization, 1982-84 (kg per year)	50	247	142	91
	18. Growth rate of per capita maize utilization, 1961-65 to 1982-84 (% per year)	2.3	1.7	2.6	1.4
Maize seed use and value	19. Area planted to improved maize as a percentage of total maize area, 1985-86	51	99	95	71
	20. Area planted to hybrids as a percentage of total maize area, 1985-86	38	99	95	63
	21. Total amount of commercial maize seed planted, 1985-86 (000 t)	901	790	222	1913
	22. Total amount of all maize seed planted, 1985-86 (000 t)	2119	805	234	3158
	23. Total value of maize seed purchased, 1985-86 (US$ million)	516	2027	345	2889
	24. Total value of all maize seed planted, 1985-86 (US$ million)	782	2031	347	3160
	25. Ratio of price of typical hybrid maize seed to grain price, 1985-86	nc	nc	nc	nc
	26. Ratio of price of commercial seed of improved varieties to grain price, 1985-86	nc	nc	nc	nc
Producer prices	27. Farm price of maize, 1985-86 (US$/t)	nc	nc	nc	nc
	28. Exchange rate, 1985-86 (local currency/US$)	nc	nc	nc	nc
	29. Ratio of farm-level nitrogen price to maize price, 1985-86	nc	nc	nc	nc
	30. Farm wage in kg of maize per day, 1985-86	nc	nc	nc	nc

nc Not calculated.
. . Missing data.
a Total world imports per capita.

Regions of the World, As Delineated for This Study

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

West Africa:
Benin
Burkina Faso
Cameroon
Cape Verde
Central African Republic
Chad
Congo
Equatorial Guinea
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Ivory Coast
Liberia
Mali
Mauritania
Niger
Nigeria
Reunion
Sao Tome
Senegal
Sierra Leone
St. Helena
Togo
Zaire

North Africa
Algeria
Egypt
Libya
Morocco
Tunisia
Western Sahara

Middle East (Countries of Asia):
Afghanistan
Bahrain
Cyprus
Iraq
Iran
Jordan
Kuwait
Lebanon
Oman
Qatar
Saudi Arabia
Syria
Turkey
United Arab Emirates
Yemen, North
Yemen, South

South Asia:
Bangladesh
Bhutan
Burma
India
Maldives
Nepal
Pakistan
Sri Lanka

Southeast Asia and the Pacific:
Brunei
Fiji
French Polynesia
Hong Kong
Indonesia
Kampuchea
Laos
Macau
Malaysia
New Caledonia
Papua New Guinea
Philippines
Samoa
Singapore
Solomon Islands
Thailand
Tonga
Vanuatu
Vietnam

East Asia:
China
Korea, North
Korea, South
Mongolia
Taiwan

Mexico, Central America, and Caribbean
Bahamas
Barbados
Belize
Costa Rica
Cuba
Dominican Republic
El Salvador
Grenada
Guadalupe
Guatemala
Haiti
Honduras
Jamaica
Martinique
Mexico
Montserrat
Netherlands Antilles
Nicaragua
Panama
Trinidad and Tobago

Andean Region
Bolivia
Colombia
Ecuador
French Guinea
Guyana
Peru
Surinam
Venezuela

Southern Cone of South America:
Argentina
Brazil
Chile
Paraguay
Uruguay

Developed Countries:

Eastern Europe and USSR:
Albania
Bulgaria
Czechoslovakia
Germany, East
Hungary
Poland
Romania
USSR
Yugoslavia

Developed Market Economies:
Australia
Austria
Belgium
Canada
Denmark
Finland
France
Germany, West
Greece
Greenland
Iceland
Ireland
Israel
Italy
Japan
Luxemburg
Malta
Netherlands
New Zealand
Norway
Portugal
South Africa
Spain
Sweden
Switzerland
United Kingdom
USA

References

CIMMYT. 1984. *Development, Maintenance, and Seed Multiplication of Open-Pollinated Varieties.* Mexico, D.F.: CIMMYT.

Boonsue, Banjerd. 1985. Some aspects of corn seed industry development in tropical Asia. Paper presented at Symposium on Cereal Seed Industry, July 8-13, Jakarta, Indonesia.

Córdova, H. 1986. Evaluación de híbridos y variedades de maíz en ensayos uniformes del Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, 1985. Paper presented at the 32nd Meeting of the PCCMCA, March 17-21, San Salvador, El Salvador.

Douglas, Johnson E., ed. 1980. *Successful Seed Programs: A Planning and Management Guide.* Boulder, Colorado: Westview Press.

Fehr, W.F., and H.H. Hadley. 1980. *Hybridization of Crop Plants.* Madison, Wisconsin: The American Society of Agronomy.

Feistritzer, W. 1975. *Cereal Seed Technology: A Manual of Cereal Seed Production, Quality Control, and Distribution.* FAO Agricultural Development Paper No. 98. Rome.

Food and Agriculture Organization. 1979-81. *Food Balance Sheets.* Rome.

____. 1982. *Seeds.* FAO Plant Production and Protection Paper No. 39. Rome.

____. Various issues. *Food Outlook.* Rome.

____. Various issues. *Production Yearbook.* Rome.

____. Various issues. *Trade Yearbook.* Rome.

Gregg, B. 1983. *Seed: Conditioning, Storage and Marketing.* Bangkok: Seed Division, Department of Agricultural Extension, Ministry of Agriculture.

International Monetary Fund. Various issues. *International Financial Statistics.* Washington, D.C.

International Wheat Council. Various issues. *Market Report.* London.

Jugenheimer, R.W. 1958. *Hybrid Maize Breeding and Seed Production.* FAO Agricultural Development Paper No. 62. Rome.

____. 1976. *Corn Improvement, Seed Production, and Uses.* New York: John Wiley and Sons.

Longmire, J., and R. Stewart. Forthcoming. An analysis of the economics of commercial maize seed production in developing countries. CIMMYT Economics Program working paper.

Paliwal, R.L., and Ernest W. Sprague. 1981. *Improving Adaptation and Yield Dependability in Maize in the Developing World.* Mexico, D.F.: CIMMYT.

Perrin, Richard K., Donald L. Winkelmann, Edgardo R. Moscardi, and Jock R. Anderson. 1979. *From Agronomic Data to Farmer Recommendations: An Economics Training Manual.* CIMMYT Information Bulletin 27. Mexico, D.F. (This publication is currently being revised.)

Seed Co-operative Company of Zimbabwe, Ltd. Information brochure. Harare.

Sprague, G.F., ed. 1977. *Corn and Corn Improvement.* Madison, Wisconsin: American Society of Agronomy.

Sprague, G.F., and S.A. Eberhart. 1977. Corn breeding. In *Corn and Corn Improvement*, ed. G.F. Sprague, 305-363. Madison, Wisconsin: American Society of Agronomy.

Tyers, R., and K. Anderson. 1986. Distortions in world food markets: quantitative assessment. Background paper prepared for World Bank, *World Development Report 1986.* Research School of Pacific Studies, The Australian National University, Canberra. Mimeo.

US Department of Agriculture. Various issues. *Feed Outlook and Situation.* Washington, D.C.: Economics Research Service.

____. Various issues. *Grains: World Grain Situation and Outlook.* Washington, D.C.: Foreign Agriculture Service.

____. Various issues. *World Crop Production.* Washington, D.C.: Foreign Agriculture Service.

Vasal, S.K., C.A. Ortega, and S. Pandey. 1982. *CIMMYT's Maize Germplasm Management, Improvement, and Utilization Program.* Mexico, D.F.: CIMMYT.

Wedderburn, R., and M. Qasim Chatha. 1982. *Seed Production: An Integral Part of an Effective Maize Program.* Islamabad: Pakistan Agricultural Research Council.

World Bank. 1986. *World Development Report 1986.* London: Oxford University Press.