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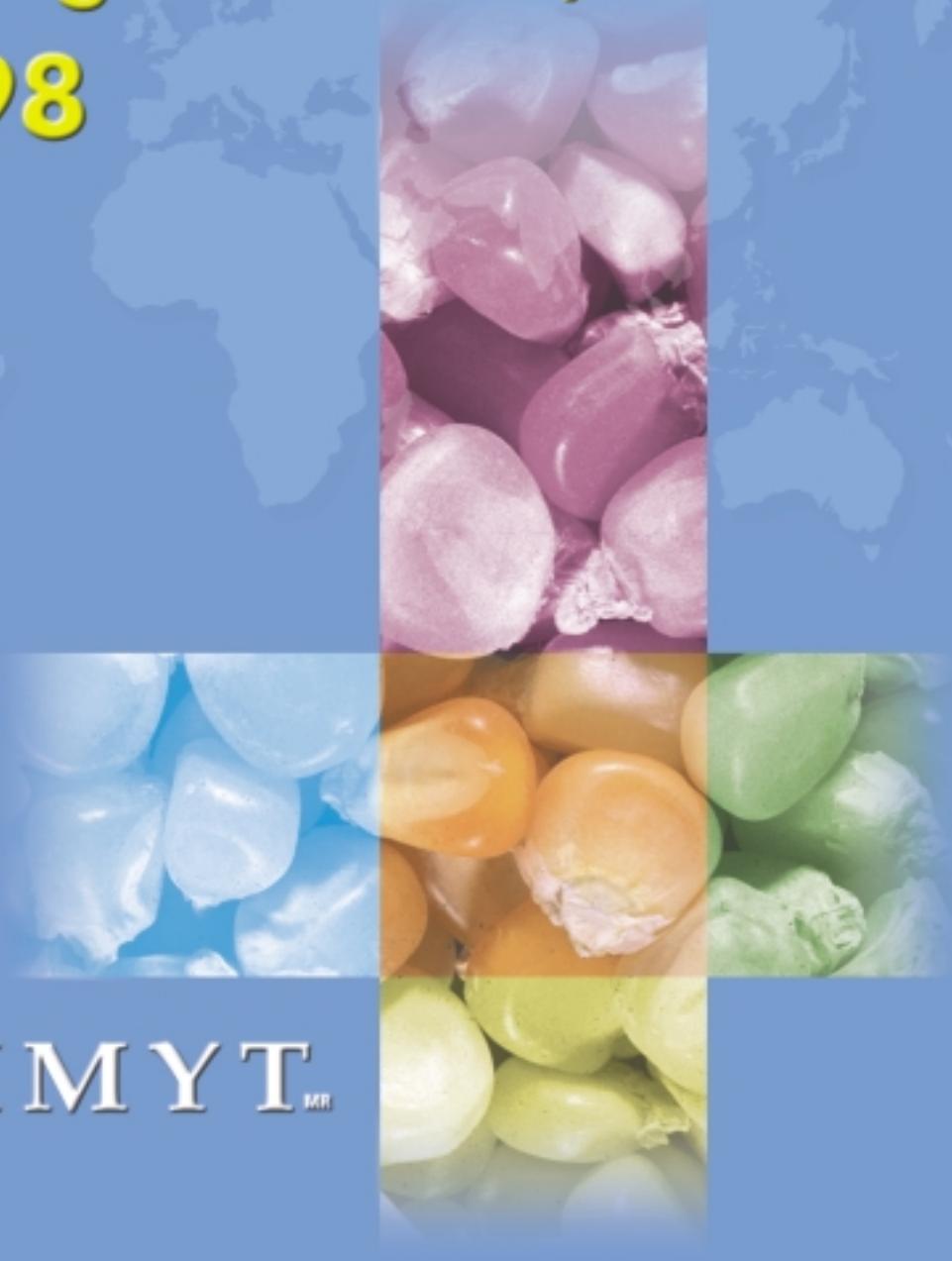

CIMMYT®

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Michael L. Morris

ECONOMICS PROGRAM

INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER (CIMMYT)

CIMMYT MR

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Abstract: This report, which updates and extends the findings of an earlier CIMMYT study published in 1994, documents the impacts of international maize breeding research in the developing world. Covering the period 1966-98, the report reviews public and private investment in maize breeding research, describes the products of public and private maize breeding programs, estimates farm level adoption of modern varieties (MVs), and estimates the gross value of additional grain production attributable to international breeding efforts. Although private companies have greatly increased their investment in maize breeding research in recent years, public maize breeding programs still play an important role, especially in breeding for subsistence-oriented farmers. Seed sales data show that the maize seed industry in many developing countries has effectively been privatized and that hybrid seed sales now dominate sales of all other seed types. The area planted to MVs continues to expand at an impressive rate. Maize MVs are currently grown on at least 58.8 million ha in developing countries, including at least 21.2 million ha planted to MVs that contain CIMMYT germplasm. The gross value of additional grain production attributable to the adoption of maize MVs in developing countries is estimated to range from US$ 3.7 million to US$ 11.1 billion per year. Analysis of varietal pedigrees shows that breeders in both the public and private sectors have made extensive use of CIMMYT germplasm. Over 54% of publicly bred MVs released in the developing world since 1966 have contained CIMMYT germplasm. The pedigrees of many privately bred cultivars are confidential, but CIMMYT germplasm was present in 58% of MVs developed by private breeding programs being sold in the late 1990s for which pedigree information is available. The gross benefits attributable to CIMMYT's maize breeding program are estimated to range from US$ 167 million to US$ 1.5 billion per year.

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Executive Summary

This report presents summary findings of a major CIMMYT-led study undertaken to document the impacts of international maize breeding research in developing countries. Designed to update CIMMYT's original global maize impacts study published in 1994, the study had multiple objectives: to estimate public and private investment in maize breeding research, to identify the products of public and private maize breeding programs, to document the use of germplasm that has been improved by CIMMYT breeders, to estimate farm-level adoption of scientifically-bred modern varieties (MVs), and to estimate the gross value of additional grain production attributable to international maize breeding research.

Data for the study were collected during the late 1990s through a survey of 371 public and private maize breeding organizations and seed companies in 37 developing countries. With the use of secondary data, the coverage for selected analyses was extended to 51 countries that together represented over 97% of the developing world's maize area.

Maize differs from most other crops in a number of respects that affect not only the way breeding efforts are organized and carried out, but also the process by which MVs are adopted by farmers and diffused across the countryside. Because of the distinctive characteristics of maize (especially the tendency for the genetic composition of successive generations of plants to change as a result of cross pollination), maize farmers who wish to maintain the genetic purity of their crops are dependent on external sources of fresh seed in a way that farmers of self-pollinating and vegetatively propagated crops are not. The need for frequent seed replacement in maize has created a large market for commercial seed and provided strong incentives for the private sector to invest in maize breeding research. Public breeding programs that work on maize thus face stiffer competition than public breeding programs that work on other crops. At the same time, because the high price of commercial maize seed places it beyond the reach of many poor farmers, public breeding programs also face a more difficult challenge in ensuring that their germplasm products reach those who need them most.

Although most maize breeding research now takes place in the private sector, the public sector remains an important player, especially in developing countries. Public maize breeding programs continue to be very productive, developing and releasing a steady stream of MVs. On aggregate, the rate at which publicly bred maize MVs are being released has increased through time and shows no sign of slowing, suggesting that public breeding programs have not suffered any decline in productivity.

Use of CIMMYT germplasm by public breeding programs has been extensive. Of the publicly bred maize MVs released in developing countries from 1966-98 and for which information is available, over one-half (54%) contained CIMMYT germplasm. Excluding MVs adapted for temperate environments (which are not directly targeted by CIMMYT maize breeders), the proportion containing CIMMYT germplasm was even higher (59%). Belying predictions that CIMMYT's role would decline as national breeding programs grow stronger, use of CIMMYT germplasm by public breeding programs has increased.

While the extensive use of CIMMYT germplasm by public breeding programs has long been known, an unexpected finding of the study is the degree to which private breeding programs also use CIMMYT germplasm. Aggregating across all developing regions, 58% of the MVs developed by private breeding programs that were sold during the late 1990s and for which information is available contained CIMMYT germplasm. The use of CIMMYT germplasm by private breeding programs varied by region, however, being high in Latin America and more modest in other regions.

Maize seed sales data collected as part of this study make clear why the private sector invests so heavily in maize breeding research. In 1996/97, maize seed sales by companies that participated in the CIMMYT survey exceeded half a million tons. This number would have been significantly higher if seed sales data had been included for companies that did not participate in the survey, especially companies operating in northern China. The seed sales data show also that the maize seed industry has effectively been privatized in most developing countries. Excluding China, where control of the maize seed industry remains in the hands of provincial and municipal governments, private seed companies outsold public seed agencies by more than ten to one. Finally, the seed sales data indicate that as in industrialized countries, in developing countries the market for commercial maize seed is dominated by hybrids. In 1996/97, seed of open-pollinated varieties (OPVs) accounted for only 6% of all seed sold by companies that participated in the CIMMYT survey.

Scientifically-bred maize MVs have diffused widely throughout the developing world. By the late 1990s, of the 94.2 million ha planted to maize in the 51 countries covered by the study, at least 58.8 million ha (62.4%) were planted to MVs, including at least 21.2 million ha (22.5%) planted to MVs that had been developed using germplasm obtained from CIMMYT.

What influences the adoption and diffusion of maize MVs? Because farmers' technology choices are determined by a large number of factors, many of which are location specific, it is difficult to analyze varietal adoption and diffusion processes at the global level. Recent empirical work clearly shows, however, that the spread of hybrid maize is influenced not only by demand side factors that affect the profitability of the technology at the farm level, but also by supply side factors that shape incentives for firms to invest in crop improvement research, seed production, and seed distribution.

What have been the economic benefits generated by international maize breeding research? Estimating the returns to agricultural research and development (R&D) presents many practical and theoretical problems. Quantifying and valuing all the direct and indirect benefits generated by international maize breeding research would be a major task far beyond the scope of this report, so we estimate only the gross value of additional maize production attributable to the adoption of maize MVs. Based on a range of plausible assumptions about the yield gains that result from MV adoption, the gross value of additional grain production attributable to the adoption of maize MVs in developing countries is estimated to range from US$ 3.7 billion to US$ 11.1 billion per year. Approximately one-half of these gross benefits can be attributed to changes in germplasm use and approximately one-half to changes in crop management practices.

CIMMYT's maize breeding program, although modest by international standards, has achieved enormous payoffs. Depending on how credit is assigned among the various organizations that contribute to international maize breeding efforts, the gross benefits attributable to CIMMYT's maize breeding program are estimated to range from US$ 167 million to US$ 1.5 billion per year. This does not include the value of non-yield benefits, such as improved grain quality, improved fodder quality, and shorter growth cycles.

International maize breeding research clearly has been successful in the past. Will it continue to be as successful in the future? Looking ahead, there is little doubt that public breeding programs will be called upon to help bring about the substantial productivity gains that will be needed if maize production is to keep pace with projected strong growth in demand. This will mean continuing to take advantage of tried-and-true conventional breeding methods, as well as exploiting new possibilities offered by emerging biotechnology-based crop improvement techniques. Changes in the economic and institutional environments in which plant breeding research is carried out will require changes in operating procedures, however. In coming years, public breeding organizations will face a number of unprecedented challenges, including how to maintain access to genetic resources, how to maintain access to cutting edge technologies, how to maintain access to genomic databases and other sources of information needed for biotechnology-assisted crop improvement research, and how to ensure adequate levels of funding. These challenges will have to be overcome if CIMMYT and its partners are to reach the millions of small-scale, subsistence-oriented farmers who still do not enjoy full access to the fruits of the international breeding system.