Maize Seed Industries

IN DEVELOPING COUNTRIES

edited by MICHAEL L. MORRIS

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LYNNE RIENNER PUBLISHERS

CIMMYT

Published in the United States of America in 1998 by
Lynne Rienner Publishers, Inc.
1800 30th Street, Boulder, Colorado 80301

and in the United Kingdom by
Lynne Rienner Publishers, Inc.
3 Henrietta Street, Covent Garden, London WC2E 8LU

Published in association with the
International Maize and Wheat Improvement Center (CIMMYT)
Apdo. Postal 6-641, 06600 Mexico, D.F., Mexico

Library of Congress Cataloging-in-Publication Data
Maize seed industries in developing countries / edited by Michael L. Morris.
p. cm.
Includes bibliographical references and index.
ISBN 1-55587-789-3 (hardcover : alk. paper). — ISBN 1-55587-790-7 (pbk. : alk. paper)
1. Seed industry and trade—Developing countries. 2. Corn industry—Developing countries. 3. Corn—Developing countries—Seeds. 4. Corn—Varieties—Developing countries. 5. Green Revolution. I. Morris, Michael L.
HD9019.S432D4457 1998
338.1'731521'091724—dc21 97-40583
CIP

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book
is available from the British Library.

Printed and bound in the United States of America

The paper used in this publication meets the requirements of the American National Standard for Permanence of Paper for Printed Library Materials Z39.48-1984.

5 4 3 2 1

Acknowledgments

No book—especially no edited book such as this—can be completed without the help of many organizations and individuals. Although space limitations preclude mentioning all those who contributed, several deserve particular mention.

First and foremost, I would like to thank the International Maize and Wheat Improvement Center (CIMMYT) for sponsoring the study leave during which most of the book was written and for committing substantial resources to its publication. My gratitude goes also to the International Food Policy Research Institute, which provided an enjoyable and intellectually stimulating environment in which to work during my study leave.

On a more personal level, I owe a special debt to the contributing authors, who not only took time from their busy schedules to write sections of the manuscript, but also tolerated my sometimes less-than-subtle efforts to push and prod their writing into a consistent and coherent whole.

Many current and former colleagues at CIMMYT provided information, answered questions, and reviewed drafts of the manuscript, including Greg Edmeades, David Beck, Javier Betrán, Surinder Vasal, Jim Lothrop, Suketoshi Taba, R. W. Wedderburn, Hugo Cordova, Daniel Jeffers, Martha Willcox, Natasha Bohorova, Mireille Khairallah, Daniel Grimanelli, Alma McNab, Prabhu Pingali, Jim MacMillan, Larry Harrington, Ricardo Calvo, Victor Hernández, and John Woolston. David Lambert and Robert Falasca of the American Seed Trade Association (ASTA) granted me access to ASTA archival materials. James Shaffer and A. Allan Schmid of Michigan State University provided useful comments on the conceptual framework chapter. Representatives of literally hundreds of public and private seed companies interviewed during various national seed industry surveys were unfailingly patient in answering what at times must have seemed like ignorant (but I hope not impertinent) questions.

The manuscript was edited at CIMMYT by Kelly Cassaday. Miguel Mellado supervised the production of figures, which were prepared by

Marcelo Ortíz, Juan José Joven, and Eliot Sánchez. Liliana Santamaría provided secretarial and administrative support. Sally Glover and Lesli Brooks Athanasoulis at Lynne Rienner Publishers coordinated the publication process.

Despite having gone to great lengths to ensure the production of a comprehensive, factually correct, and well-balanced book, the controversial nature of the subject matter makes me suspect that not everybody will be satisfied by the final result. I gladly accept responsibility for whatever errors and deficiencies remain.

—Michael L. Morris

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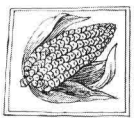
Maize in the Developing World: Waiting for a Green Revolution

MICHAEL L. MORRIS



Of all the inputs used in agriculture, none has the ability to affect productivity as much as seed. A seed is a living organism that carries the genetic properties of plants. These genetic properties place an upper limit on yield potential and influence the productivity of other inputs by determining the ability of plants to convert sunlight, water, air, soil, and other nutrients into biomass. Because plants vary in terms of their ability to perform this conversion, seed choice is critically important in agriculture. If farmers can obtain seed of cultivars that perform well under local conditions, the efficiency with which other inputs are converted into economically valuable outputs increases, and productivity rises. At the same time, improved seed can make a contribution to productivity independent of other inputs. Thus, it is not surprising that technical change in agriculture frequently is driven by changes in crop varieties, which in turn depend on farmers having reliable access to improved seed.

Looking back over the global history of crop varietal changes, it is apparent that maize has followed a very different path from that followed by other leading cereals. The so-called green revolutions in rice and wheat are by now well-known. During the late 1960s and early 1970s, improved semidwarf varieties of rice and wheat were introduced into some of the developing world's most populated countries. When grown with increased levels of fertilizer and an assured water supply, these modern varieties (MVs) performed significantly better than the traditional varieties (TVs) they replaced, leading to substantial production increases and higher incomes for millions of farmers who adopted the technology.[1] Following their introduction, rice and wheat MVs spread rapidly throughout many of the irrigated zones where rice and wheat cultivation was concentrated, leading to dramatic increases in food production in a number of countries that a short time earlier had been haunted by prospects of widespread famine. In subsequent years, rice and wheat MVs spread gradually into

less favorable environments, including many nonirrigated areas with relatively modest production potential. Meanwhile, in the irrigated zones that had first been affected, the original MVs were replaced by second- and third-generation MVs, helping to fuel slow but steady yield increases on the order of 1% per year that have continued to this day.

In the case of maize, a phenomenon equivalent to the green revolutions in rice and wheat has not yet occurred, at least not in most of the developing countries. Despite extensive efforts to promote improved production technologies for maize, about half of the developing world's maize area continues to be planted to TVs that have never received the attention of a formal plant breeding program. The proportion of maize area that is irrigated lags behind that of rice and wheat, and use of fertilizer and other purchased inputs on maize remains relatively modest. The stark contrast between the experiences of rice and wheat on the one hand and the experience of maize on the other is particularly puzzling in view of what has happened in the industrialized world, where improved maize hybrids have been extensively adopted and use of purchased inputs on maize is high.

If much of the developing world has thus far failed to experience a green revolution in maize, it is not because improved production technologies have been lacking. Investment in maize research has been extensive, and this investment has produced results. Plant breeders have developed many improved varieties and hybrids that clearly outperform the materials grown by farmers. Similarly, crop management specialists have identified improved management practices capable of significantly boosting productivity. Yet even though these technologies have shown marked superiority under experimental conditions, many have failed to spread beyond demonstration plots. Thus, the problem is not that improved maize varieties and hybrids are lacking, as well as the improved management practices that allow them to express their full genetic potential, but rather that the improved technologies that are available have not reached the farm level. Why this is so, and what can be done to improve the situation, is the subject of this book.

Key Role of Maize Seed Industries

Maize (*Zea mays* L.) differs from rice and wheat in several respects that have important implications for the development and spread of improved germplasm. Because they are self-pollinating crops, when rice and wheat reproduce, each generation of plants retains the essential genetic and physiological identity of the preceding generation. This means farmers can safely replant rice and wheat seed harvested from their own fields, giving them effective control over the technology embodied in improved

germplasm. Farmers can set aside a portion of their harvest for use as seed in future cropping seasons, as long as they are careful to avoid mixing seed of different varieties. Furthermore, if they so choose they can easily distribute seed to other farmers. This is precisely what happened during the green revolutions in rice and wheat: After relatively small quantities of seed were released by public breeding programs, rice and wheat MVs quickly spread through farmer-to-farmer seed exchanges, with relatively little involvement by any sort of formal seed industry.

Maize presents a different story, however. Because it is a naturally cross-pollinating crop, when maize reproduces, much depends on whether the pollen used to fertilize a given kernel comes from the same plant or from a different plant. Unlike rice and wheat plants, when maize plants self-fertilize, the resulting progeny are often characterized by undesirable traits, such as reduced plant size and low yields.[2] But when maize plants cross-fertilize, some of the resulting progeny tend to demonstrate desirable traits, such as increased plant size or high yields. Commonly referred to as "hybrid vigor," this phenomenon is attributable to the complementary action of favorable genes and is frequently exploited by plant breeders in their efforts to develop commercial materials. Unfortunately, the benefits of hybrid vigor do not persevere across generations. When seed harvested from cross-pollinated maize plants (known as F_1 hybrids) is replanted, performance in the resulting progeny (known as F_2 hybrids) decreases because of the inbreeding phenomenon referred to earlier. The size of the decrease in performance depends on the nature of the original F_1 hybrids. If the F_1 plants were single-cross hybrids formed from highly homozygous inbred lines, the yield loss in the F_2 generation may be as great as 35–40%. If the F_1 plants were double-cross hybrids formed from less highly inbred parents, the yield loss will be more modest, usually on the order of 10–15%.[3]

These two characteristics of maize—its tendency to deteriorate through inbreeding and its ability to demonstrate hybrid vigor—affect the degree of control exercised by farmers over the technology embodied in seed. Because of the decrease in performance between F_1 plants and subsequent generations, farmers who choose to grow hybrids in effect forfeit the option of saving a portion of their harvest to use as seed in the following cropping cycle.[4] Farmers who choose to grow open-pollinated varieties retain the option of saving a portion of their harvest to use as seed in the following cropping cycle, but they must be careful to maintain the genetic purity of successive crops grown from replanted seed (e.g., by physically isolating plots and by staggering planting dates to prevent cross-pollination between varieties).

With on-farm seed production either technically difficult (in the case of hybrids) or inconvenient and costly (in the case of varieties), maize farmers must acquire fresh seed for each planting if they want to be certain

of maintaining a high level of genetic purity in their crops. In and of itself, the fact that maize farmers depend on external sources of seed does not necessarily affect the development and diffusion of improved germplasm. On the face of it, there seems to be no good reason maize varietal development, seed production, and seed distribution activities cannot be performed by specialized organizations. Nevertheless, the empirical record is not encouraging, at least not in most developing countries, where decades of sustained investment in maize research and development activities have resulted in relatively modest impacts. The implication is that past approaches have not worked very well and may have to be modified.

For better or for worse, in many countries the need to rethink maize research and development strategies comes at a time when public support for agriculture is stagnating or even declining. Forced to re-evaluate the desirability of continuing long-standing government spending programs, policymakers frequently have chosen to relieve pressure on overburdened public-sector budgets by encouraging the privatization of selected activities traditionally carried out by public agencies. Plant breeding research, which offers obvious opportunities for commercial gain, has often been among the first activities targeted for privatization.

Judging from the experience of many industrialized countries, the maize seed industry indeed appears to be a suitable candidate for privatization. In the United States, Canada, and most of the member states of the European Community in which maize is an important crop, maize varietal development, seed production, and seed distribution are now performed largely by private firms. The industry is populated by large transnational corporations whose names are familiar: Pioneer, Sandoz, DeKalb, Limagrain, Novartis, ICI-Zeneca, Cargill. The seed divisions of these corporations have grown and prospered because they have been able to identify the germplasm needs of commercial farmers, develop hybrids that successfully meet those needs, produce high-quality seed, and distribute that seed at attractive prices. The undeniable success of many seed companies has heightened the widespread perception that private companies are well equipped to handle maize varietal development and seed production. In many developing countries, the result has been a groundswell of support for privatizing the maize seed industry.

Not everybody is comfortable with the idea of a global maize seed industry consisting exclusively of private companies, however. Some observers argue that privatization poses a risk because the quest for profits could lead private seed companies to act in ways that are not necessarily in the best interest of all producers and consumers. Private companies clearly have economic incentives to serve the needs of large-scale commercial producers who represent a potentially lucrative market for seed, but they probably have much less reason to address the needs of small-scale subsistence farmers who may be unable or unwilling to purchase seed regularly.

The lack of success achieved by public-sector organizations in bringing about a green revolution in maize suggests that it may be desirable to encourage private companies or nongovernmental organizations to play a greater role in disseminating improved maize varieties and hybrids, particularly in the developing world. Complete withdrawal of public organizations from the maize seed industry, however, would probably be undesirable for several reasons. First, private firms are unlikely to engage in activities that offer no prospects for short- or medium-term profits, including germplasm collection and conservation, as well as many types of basic research. Furthermore, private seed companies will tend to neglect small-scale farmers in marginal production environments who, because of their dispersed distribution, special germplasm requirements, and modest purchasing power, do not represent an attractive market. Thus, increased privatization will have to be encouraged in ways that ensure that the needs of the widest possible range of producers and consumers are effectively addressed. Privatization of the maize seed industry will fail if the old state monopolies are simply replaced by new private ones.

Objectives

Following a long period of relative stability, the world food economy has begun to change in ways that are likely to have important consequences for millions of producers and consumers of maize. In many developing countries, private seed companies are beginning to assume a leading role in generating improved maize varieties and hybrids, producing commercial seed, and distributing that seed to large numbers of farmers. Meanwhile, the government research institutes and state seed agencies that have traditionally performed those functions are often being forced to scale back their level of activity. As a result, responsibility for the development and dissemination of improved production technologies for maize—which in earlier times would have been considered too important to entrust to the private sector—has begun to shift away from the public domain.

Thus far, moves to privatize national maize seed industries seem to have had largely positive results, as evidenced in many countries by recent dramatic growth in the adoption of hybrids, expansion in the area planted to improved germplasm, and a surge in national average maize yields. Yet despite these encouraging signs, it is legitimate to ask where the changes will ultimately lead. If current trends continue, will maize farmers in developing countries always be able to obtain a wide range of improved germplasm and related production technologies at affordable prices? Will consumers always have access to adequate supplies of maize at affordable prices? Will efficient forms of industrial organization automatically emerge for carrying out seed research, seed market development, seed production,