RESEARCH AT A GLANCE

Genetic Resource Policies

Promising Crop Biotechnologies for Smallholder Farmers in East Africa: Bananas and Maize

Brief 23

Predicting Farmer Demand for *Bt* Maize in Kenya

Melinda Smale, Hugo De Groote, and George Owuor

The Importance of Maize Improvement in Kenya

Agriculture is the leading sector in Kenya's economy, providing employment to more than two-thirds of the population. Maize continues to be the major food staple, and Kenyans have one of the highest rates of maize consumption per capita in Africa. Kenya experienced spectacular maize breeding successes in the 1960s and 1970s, with diffusion curves for hybrids as steep as those of the U.S. Corn Belt in preceding decades (Gerhart 1975). In the past few decades, however, a number of factors have contributed to stagnating national maize production, including a secular (long-term) decline in soil fertility and decreasing public research investments. Meanwhile, improved varieties of maize have diffused more gradually into more marginal production environments where yield potential is lower. Maize scientists in Kenya generally concur that better combinations of resistance and tolerance traits are the key to boosting maize yields among smallholders, given that they are unlikely to invest heavily in intensifying their production in the near future.

Stemborers, in particular, inflict significant yield losses. Despite these losses, which are estimated at 13.5 percent per annum—roughly equivalent to annual maize imports (De Groote et al. 2004b)—only a very small proportion of farmers use insecticides to control stemborers, mainly because of high costs and labor requirements. According to participatory rural appraisals (PRAs) carried out in different regions of Kenya under the project, Insect-Resistant Maize for Africa (IRMA), farmers perceive stemborers, along with storage pests, to be the most important pest problem (De Groote et al. 2004a).

Genetic transformation offers the opportunity to insert *Bt*-based resistance into a number of Kenya's maize varieties. The choice of host variety can have social consequences as well as implications for the rate of return on research investment. This is because Kenya's maize hybrids and improved varieties have been bred to suit the specific characteristics of the nation's vast and disparate production environments. In addition, within these environments, the farmers most likely to adopt *Bt* maize varieties differ in terms of their levels of wealth, assets, education, and income.

Kenya's east is characterized by lowland tropics on the coast, and then, moving westward, dry mid-altitude and dry transitional zones (Hassan 1998). Although these three zones cover nearly 30 percent of the maize area in Kenya, they only produce an estimated 11 percent of the crop. The moist-transitional zone (NE, E, SE) straddles the highland tropics. Yields are considerably higher in these zones, which produce 80 percent of the maize in Kenya on 30 percent of the area. The sixth zone, the moist mid-altitude

About the Authors

Melinda Smale *is a senior research fellow in the Environment and Production Technology Division of the International Food Policy Research Institute (IFPRI) and was also a senior economist with the International Plant Genetic Resources Institute (IPGRI) at the time this research was conducted.*

Hugo De Groote *is an economist in the Social Sciences Group of the International Maize and Wheat Improvement Center (CIMMYT), based in Mexico.*

George Owuor *was a lecturer at Egerton University, Kenya, and a research analyst for the International Maize and Wheat Improvement Center (CIMMYT) at the time of this research.*

region around Lake Victoria, contributes around 9 percent of the nation's maize (Figure 1).

In the highland tropics and parts of the moist transitional zones, hybrids account for a large proportion of the maize area planted and almost all farmers grow at least some hybrids, although some farmers continue to grow local maize. H511 and H614 are still the most frequently grown hybrids in the high-potential zones. Adoption rates remain lower in the more marginal maize producing environments. Local varieties are most frequently grown by farmers in the drylands, although improved open-pollinated varieties cover the greatest percentage of the maize area. Comparison of the results of surveys conducted in 1992 (Hassan 1998) and 2002 (IRMA baseline survey, described in Brief 19 and reported here) indicates that the percentage of farmers growing hybrids in the coastal region nearly doubled in that decade. Similar percentages grew improved maize varieties in the dry transitional zone in the survey years, but the use of improved varieties in the dry mid-altitude zone appears to have declined between 1992 and 2002 (Table 1).

Determinants of Farmer Demand for Host Varieties

In Kenyan maize, most potential host varieties for *Bt* genes are hybrids and improved open-pollinated varieties, although there are several local varieties that are recognized by plant breeders and extensively grown by farmers. This situation stands in contrast to that for East African highland bananas, where most potential host varieties are local. To examine the factors that influence farmer demand for seed of potential *Bt* host varieties, 2 of the more than 40 maize varieties identified in the IRMA baseline survey were selected as illustrative examples from among those most frequently grown by farmers during the major rainy season. The first, H614, is a hybrid cross first released in the 1970s, bred for the high-potential maize growing environments at higher altitude and with longer seasons. The second, Mdzihana, is a local variety recognized by both maize breeders and farmers for its distinctive traits, and grown only in the coastal lowland tropics. Regression analysis was used to predict use of the varieties and identify the determinants of use.

The coastal low tropics has remained a distinct maize production zone for cultural reasons and because it is marginal to the national economy. Cash incomes generated through off-farm work are relatively low, food in the shops is in irregular supply, and farm households try to attain a high degree of self-sufficiency in maize (Waaijenberg 1994). Soils are sandy and poor, and rainfall is unreliable. The maize crop in this humid zone is very susceptible to stemborers, molds, and maize weevils.

A regression analysis was performed to identify the determinants of variety use (Table 2). The more tolerant a variety is to stemborers, the greater the proportion of the maize area a farmer allocates to it. The effect on the

Table 1—Adoption of improved maize in Kenya, by maize growing environment, 2002

	Farmers (percent)			Maize area (percent)		
Zone	Hybrids	Local varieties	Improved open-pollinated varieties	Hybrids	Local varieties	Improved open-pollinated varieties
High tropics	94	9	0	94	0	6
Moist transitional east	98	16	0	93	0	7
Moist transitional northeast	99	12	3	97	1	4
Moist transitional southeast	72	41	1	68	1	32
Moist mid-altitude	38	83	3	27	2	71
Dry transitional	21	77	17	16	12	73
Dry mid-altitude	9	72	32	6	28	66
Low tropics	63	46	20	52	13	35

Source: KARI/CIMMYT (2002/03).

Note: Farmer data total to more than 100 percent because farmers grow combinations of hybrids, improved open-pollinated varieties, and local varieties.

Table 2— Factors that influence farmer demand for seed of potential *Bt* host varieties

Variable	H614	Mdzihana
Expected yield	+	0
Perceived tolerance to stemborers	+	+
Education of women (years)	+	0
Education of men (years)	–	–
Value of cattle (Ksh)	+	+
Value of gifts and transfers (Ksh)	0	0
Share farmland in maize (percent)	0	–
Share of farmland with fertile soil (percent)	0	0
Previous extension contact	0	0
Hired labor in the village	–	0
Market access	+	0

Source: Owuor, Smale, and De Groote (2004).

Note: + indicates a positive association between the variable and farmer demand for seed, – indicates a negative association between the variable and farmer demand for seed, and 0 indicates no statistical association between the variable and farmer demand for seed.

share of maize area planted to the variety is even larger when it is a local variety in the lowland tropics, in part because local varieties have greater tolerance to stemborers, and in part because yield losses from stemborer are greater. These findings indicate that farmers would show greater interest in using maize varieties that are resistant to stemborers, whether a hybrid or a local variety. Higher expected yields also contribute to greater demand for hybrid seed. Commercial producers, such as those in the highlands, will focus on using the most profitable maize variety. Farmer interest in hybrid maize seed often increases with their level of education; however, the tendency for more highly educated male farmers to be drawn away from agriculture in general, and from staple food production to other cash crops, may reduce the demand for hybrid maize seed. Households in which educated individuals shift from cultivating maize to other, more profitable, activities, spend less on maize seed and tend to purchase maize with cash earned from other sources. The local maize variety contributes to meeting subsistence needs not covered by purchased, lower quality grain. The negative effect of education of male farmers on demand for hybrid maize is contrasted by the positive effect of education for female farmers, because women remain heavily involved in the production of food.

Wealth in livestock assets is positively related to demand for maize seed in both high- and low-potential zones but for different reasons. In the high-potential zone, greater wealth is associated with higher shares of maize area in the major hybrid. In the coastal region, households with more livestock are found in the drier areas located inland from the coast, where local varieties outperform improved types. In the low-potential area on the coast, the more important maize is in the cropping system of the farm, the smaller the proportion of maize area farmers allocate to the local variety, Mdzihana. For example, input-market access increases the chances that a farmer will grow the hybrid maize. A greater intensity of hired labor in the village is associated with smaller proportions of maize area planted to H614. One explanation for this result could be that more labor is devoted to cash crops than to maize because the economic returns to labor are higher.

Based on the econometric estimation, it is possible to develop a profile of the farmers most likely to use the variety if transformed (Table 3). Again, we use H614 and Mdzihana as examples. Inserting the *Bt* gene into Mdzihana would target households with less family labor, less educated men and women, and half the average income received through gifts and transfers. These smallholder farmers have about one-fifth of their wealth in livestock assets, and only 17 percent have income from growing cash crops. They have less fertile land than those who do not grow Mdzihana, but, nevertheless, they farm larger maize areas and are more dependent on maize as a crop. Reducing crop losses may have a greater impact on the welfare of individual households in more economically marginalized zones.

Clearly, the greatest rate of return to research investment would accrue from inserting *Bt* genes into maize varieties grown in the high-potential zones. About 80 percent of the estimated value of crop losses to stemborers in Kenya occurs in the moist transitional and highlands zones, where adoption rates for maize hybrids are greatest and the nation's surpluses are produced. By contrast, only 12.5 percent of the national value of crop losses to stemborers occurs in the lower potential, dry and lowland tropics. The estimated marginal value per hectare from *Bt* insertion, however, is equal in the high- and low-potential zones (De Groote et al. 2003). Although maize yields are much higher in the high-potential zone, losses to the stemborer species Chilo partellus, against which the *Bt* genes currently identified are very efficient, are considerably less. The distribution of stemborer species indicates that the foremost species in the higher potential zone is Busseola fusca, for which an effective *Bt* gene has yet to be identified.

The Kenya national maize program will have the opportunity to insert *Bt* genes into a range of materials at relatively low cost compared with some other crops. However, the findings presented in this brief illustrate the point, also made in Brief 22, that genetically transformed varieties, like varieties improved by crossing or selection, will typically have differential impacts across farmers, social groups, and regions.

References

De Groote, H., B. Overholt, J. O. Okuro, and S. Mugo. 2003. Assessing the potential impact of *Bt* maize in Kenya using a GIS based model. Selected paper, XXVth Conference of the International Association of Agricultural Economics, Durban, August 16–22, 2003.

De Groote, H., J. O. Okuro, C. Bett, L. Mose, M. Odendo, and E. Wekesa. 2004a. Assessing the demand for insect resistant maize varieties in Kenya combining participatory rural appraisal into a geographic information system. In *Participatory plant breeding and participatory plant genetic resource enhancement: An Africa-wide exchange of experiences*, edited by L. Sperling, J. Lancon, and M. Loosvelt. Proceedings of a workshop held in M'bé, Côtes d'Ivore, May 7–10, 2001. Cali, Colombia: CGIAR Systemwide Program on Participatory Research and Gender Analysis.

De Groote, H., J. O. Ouma, M. Odendo, and L. Mose. 2004b. Estimation of maize crop losses due to stemborers: Preliminary results of a national field survey in Kenya. In *Integrated approaches to higher maize productivity in the new millenium*, edited by D. K. Friesen and A. F. E. Palmer.. Proceedings of the 7th Eastern and Southern Africa Regional Maize Conference, Nairobi, Kenya, February 11–15, 2002. Mexico City: International Maize and Wheat Improvement Center.

Table 3— Profiles of farm households most likely to grow potential *Bt* host varieties

Profile	H614	Mdzihana
Adult household members	8.14	5.10
Education of men (years)	8.86	6.28
Education of women (years)	7.57	3.24
Annual gifts and transfers (Ksh)	18,817	9,667
Annual credit received (Ksh)	2,585	153
Value of cattle (Ksh)	29,116	5,964
Share growing cash crops (percent)	68	17
Farm size (ha)	2.83	4.11
Maize area (ha)	0.34	3.23
Share of farm area in maize (percent)	35.4	75.1
Share of farm area with fertile soil (percent)	5.6	1.0

Gerhart, J. 1975. The diffusion of hybrid maize in western Kenya. Ph.D. thesis, Princeton University. Abridged by International Maize and Wheat Improvement Center (CIMMYT), Mexico.

Hassan, R. M., ed. 1998. Maize technology development and transfer: A GIS application for research planning in Kenya. London: CAB International for the Overseas Development Institute.

KARI/CIMMYT (Kenya Agricultural Research Institute and International Maize and Wheat Improvement Center). 2002/03. Insect-Resistant Maize for Africa (IRMA) baseline survey 2002/03. Nairobi and Mexico City: KARI and CIMMYT.

Owuor G., M. Smale, and H. De Groote. 2004. Crop biotechnology for Africa: Who will gain from adopting *Bt* maize in Kenya? Paper presented at the American Association of Agricultural Economics Annual Meeting, Denver, Colorado, August 1–4, 2004.

Waaijenberg, H. 1994. Mijikenda agriculture in the coast province of Kenya: The agronomy of an “unsuitable crop.” In Agriculture in the coast province of Kenya: Peasants in between tradition, ecology and policy. Wageningen, the Netherlands: University of Wageningen.

Further Reading

Byerlee, D., and P. W. Heisey. 1996. Past and potential impact of maize research in Sub-Saharan Africa. Food Policy 213: 255–277.

De Groote, H. 2002. Maize yield losses from stemborers in Kenya. Insect Science Applications 22 (2): 89–96.

De Groote, H., J. O. Ouma, M. Odendo, and L. Mose. 2004. Estimation of maize crop losses due to stemborers: Preliminary results of a national field survey in Kenya. In Integrated approaches to higher maize productivity in the new millennium, D. K. Friesen and A. F. E. Palmer, eds. Proceedings of the 7th Eastern and Southern Africa Regional Maize Conference, Nairobi, Kenya, February 11–15, 2002. Mexico City: International Maize and Wheat Improvement Center (CIMMYT).

For further information, please contact Melinda Smale (m.smale@cgiar.org).

This work was made possible in part by support from the Swedish International Development Agency (SIDA), System-wide Genetic Resources Program of the CGIAR, European Commission, and the U. S. Agency for International Development (USAID).

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

2033 K STREET, NW, WASHINGTON, DC 20006-1002 USA
TEL +1.202.862.5600 FAX +1.202.467.4439 EMAIL ifpri@cgiar.org WEB www.ifpri.org