RESEARCH AT A GLANCE

# Genetic Resource Policies

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

Brief 25

## Biodiversity of Maize on Farms in Kenya

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In recognition of the importance of genetic resources, international agreements, such as the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), encourage national governments to support the sustainable use and management of genetic resources on farms and in gene bank collections. To design initiatives to support the local management of crop biological diversity in farming communities, an understanding of the social and economic factors that determine the observed levels is needed.

Diversity among either improved varieties or local varieties, or both, can generate private value to farmers and public value to society. In difficult growing environments where market opportunities are limited, such as the less-favored areas of Kenya, farmers manage production risk ex ante through diversifying crops and varieties. Substantial spillovers of materials bred for high-potential environments into less favorable environments have occurred, although most improved varieties do not outperform local varieties for all attributes of importance to farmers (Hassan et al. 1998). Farmers often choose to grow improved and local varieties simultaneously because the genetic traits in one category complement those found in another. Kenyan maize breeders also consider that some local varieties growing in harsher environments hold potential value for local adaptation and specific traits.

In zones with high productivity and good markets, such as the highlands of Kenya, commercial farmers may better meet their objectives by growing the single most high-yielding maize variety and reallocating land from food crops to more profitable cash crops. Even here, however, diversity remains important. The genetic structure of improved varieties is developed by plant breeders, and the risk associated with widespread cultivation of the same variety is uniformity in traits conferring resistance to biotic pressures. Uniformity in plant resistance mechanisms makes the crop vulnerable to mutations in pests or pathogens, and if a mutation emerges that overcomes the resistance, an epidemic may ensue. Consequently, some plant breeders seek to cross multiple sources of resistance into the same varieties (through race nonspecific or horizontal resistance strategies). Reducing crop vulnerability to yield losses benefits both farmers and society in general.

By comparison, the genetic structure of local varieties is shaped by farmer selection and natural selection processes. Often, these varieties are managed as more genetically heterogeneous units. Nonetheless, their sources of genetic resistance to a particular pest or disease may be narrow.

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## Maize Gene Pools in Kenya

The origins of maize in Kenya provide insights into the varieties cultivated today. The most generally accepted hypothesis is that after being taken from the Americas to Europe in 1494, maize was introduced to the African continent through several routes during the 16th century. There are few written accounts about the diffusion of maize. Linguistic evidence suggests that the crop penetrated the interior of tropical Africa from the coastal lowland tropics, as part of the Portuguese trade with East Africa (Miracle 1966). On the East African coast, maize was given many names, including the Swahili name muhindi (the plant of India), and pemba, the name of the island in the Indian Ocean on which 16th century Portuguese planters cultivated food plants (including maize) to supply their garrison. Although maize was probably known throughout Kenya by the 1880s, up until World War I it seems to have been important as a staple food only along the coastal lowlands in the southeastern corner of the country. Maize's transition to a major crop in Kenya occurred during World War I, when disease in millet led to famine, and millet seed was consumed rather than planted.

M. N. Harrison, Kenya's chief maize breeder during the colonial period when the first plant breeding program was initiated, classified the nation's maize types into four pools (Harrison 1970). By the turn of the century, the Caribbean flint types of maize dominated the crop area along the East African coast and had spread inland along trade routes, although maize continued to be a minor crop. The rise in the importance of maize occurred after the introduction of a different gene pool from South Africa, derived from white dent types brought there earlier from North America. Harrison reports that through crib selection by European farmers, "Kenya Flat White" emerged as a recognized, reasonably stable population. Harrison reported two other minor types. The first, identified as Cuzco, was a high altitude race with strong purple pigmentation that originated from Peru. Called Githigu in Kikuyu, Cuzco is believed to have been brought by missionaries before World War I, and a variety by the same name is still grown in Kenya. The second minor type, called Local Yellow, was declining in use at the time Harrison noted it. This type was as attributed to a combination of early introductions of Caribbean flint types and later introductions of yellow dents from the Americas via South Africa.

The first improved maize variety released in Kenya was the Kitale Synthetic II (an open-pollinated maize variety [IOPV] released in 1961), based on inbred lines from the Kenya Flat White complex. The chief maize breeder "felt the need to widen the genetic base of the Kitale program," and while "nothing of value" had come from earlier testing of U.S. Corn Belt, European, South Africa, Rhodesian, and Australian materials, "the great diversity of center-of-origin material from similar ecological conditions to those of East Africa, close to the Equator with a wide range of altitude, had never been tried" (Harrison 1970, 38). In 1958, Harrison returned from a trip to Mexico and Colombia, funded by the Rockefeller Foundation, with exotic breeding material. After screening them, he made numerous top-crosses of exotic materials with Kitale Synthetic II, the most outstanding of which was a cross with an unimproved Ecuadorian landrace (Ecuador 574). The result was Kenya's first varietal hybrid (H611), released in 1964. Since that time, H611 has been the basis of all hybrids developed by the national program.

The Insect-Resistant Maize for Africa (IRMA) baseline survey confirms that more than 40 distinct maize varieties are currently grown across maize-growing ecologies in Kenya. Kenyan smallholders generally cultivate both local and improved varieties but utilize only a few varieties per farm. Maize diversity is much higher across farms within a community. This finding reinforces the argument that, both because of social factors and the genetic properties of maize, understanding the determinants of local crop biodiversity at the scale of the community is important for the design of national conservation programs envisaged in the CBD.

Statistical associations provide insights into factors that enhance the prospects for the sustainable management of maize biological diversity for present and future generations in Kenya. If anything, wealth, income, and educational levels in communities are associated with a greater richness and equitability in the spatial distribution of maize varieties. More intensive local labor markets reduce diversity, probably because of the rising opportunity costs of time as the local economy develops.

Results suggest that maintaining diversity among modern varieties is important in the high-potential

## Table 1— Maize varieties grown in Kenya during the major rainy season

| Zone | Hybrids | Improved open-pollinated varieties | Local varieties |
|---|---|---|---|
| High tropics | CG4141 | Katumani | 6-Choge |
| | H511 | | Cheberon |
| | H512 | | Githigu |
| | H614 | | High shoot |
| | H622 | | Miezi 3 |
| | H625 | | No.8 |
| | H526 | | Nyamula |
| | H627 | | Nyandarua |
| Moist transitional | H511 | Katumani | 6-Choge |
| | H513 | Maseno double-cobber | Cheberon |
| | H614 | | Endere |
| | H622 | | Githigu |
| | H625 | | Kuria local |
| | H626 | | Maisukha |
| | H627 | | Miezi 3 |
| | H628 | | Migori |
| | H629 | | No.8 |
| | PH1 | | Nyamaragoli |
| | PH3253 | | Nyamula |
| | PH9401 | | Rachar |
| | Dryland Hybrid 1 | | |
| Moist mid-altitude | H511 | Katumani | Amanyala |
| | H513 | | Anzika |
| | H614 | | Msamaria |
| | H622 | | No.8 |
| | H625 | | Nyamilambo |
| | PH3253 | | Nyamula |
| | | | Nyauganda |
| | | | Oking |
| | | | Ongech |
| | | | Opapari |
| | | | Otalii |
| | | | Rachar |
| | | | Sipindi |
| Dryland tropics | CG4141 | Katumani | Kangundo |
| | H511 | Makueni | Kikamba |
| | H513 | | Kinyanya |
| | H625 | | |
| | H627 | | |
| | H628 | | |
| | PH3253 | | |
| Dryland mid-altitude | CG4141 | Dryland Composite 1 | Kikamba |
| | H511 | Katumani | Kinyanya |
| | PH3253 | Makueni | |
| Low tropics | PH1 | Coast Composite | Kanjerenjere |
| | PH4 | Katumani | Mdzihana |
| | | | Mengawa |
| | | | Mgiriama |
| | | | Mungindo |
| | | | Mwangongo |
| | | | Zongo |

Source: KARI/CIMMYT (2002/03).

Note: The variety list is drawn from a statistical sample and is not a census of all varieties grown. While the representation is good, some varieties grown may not be listed.

zones, while maintaining diversity among local varieties is of greater importance in the low-potential zones. One key conclusion is that variations in the travel time to the nearest market reduces the spatial evenness of both the local and improved maize varieties, albeit for opposite reasons. Farmers growing local varieties are even more reliant on saved seed and their own genetic materials to meet their needs when they live farther away from markets. Farmers growing improved varieties, by contrast, have higher transactions costs in procuring seed when they are located further from markets, leading to slower rates of hybrid seed replacement and lags in variety change, both of which negatively impact yields. Kenya Seed Company's pan-territorial, uniform pricing policy for maize masks important differences in transaction costs and seed types, potentially distorting the variety choice decisions of farmers. While other companies have different pricing strategies, their market share, while increasing, is estimated at less than 10 percent.

The range of farmer-managed, local materials grown by Kenyan farmers attests to their continued private value despite the economic development of the country and high adoption rates for improved maize varieties. Supporting local management of more spatially diverse maize materials in Kenya could be accomplished by different means depending on the improvement status of the varieties. In the case of improved maize varieties, public investments could be directed to the seed industry to stimulate development of high-quality seed and improve both seed production and local seed supply in order to meet both spatial and temporal seed demand for a broad range of improved varieties. In the case of local varieties, the lower potential zones might be considered as possible sites for community-based on-farm conservation programs. Any such programs should be designed to enhance the private value of local varieties through innovative breeding or other community-based initiatives, since a greater proportion of households in low-potential areas are food-deficient and have limited nonfarm income.

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