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COMMUNITY-BASED MAIZE SEED PRODUCTION IN COASTAL LOWLAND KENYA.

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ABSTRACT

Farmers at the Kenyan coast lack a supply of affordable and timely maize seed. They often use unimproved and non-recommended seed, leading to poor yields. Since private companies have switched to hybrid maize varieties, the popular improved open pollinated variety, Coast Composite, is no longer offered in the market. To make this seed again available to the farmers, a seed production project was launched at the Coast. Pre-basic and basic seed of Coast Composite and two local varieties (Mungindo and Mengawa) was produced on-station, on 0.25 ha per variety and seed type, in total 1.5 ha. Commercial seed was produced by 4 community groups and 2 farmers in 5 sites, between 0.25 and 1.5 ha per site (4 ha in total). Isolation of plots from other maize farms at pollination was by time and space, and the seed plots were naturally random pollinated. Selection was done based on desirability of plant and ear characteristics before and after pollen shed. Emasculation before pollen shed and plant cutting above the ear was the roguing technique used. Total seed production was 2.8 tons. Seed was sold at harvest, on the spot and in bulk, at Ksh.100 per kilogram compared to the current price for improved seed of Ksh.140 per kilogram. The demand for locally produced improved seed is large, but the costs of the project are high. Future activities should emphasize an increased production as well as a higher recovery of costs, in particular inputs such as basic seed, fertilizer and insecticide. Finally, the requirements for certified seed are prohibitively expensive for small-scale farmers and the market is too small for large-scale producers. Therefore, alternative delivery systems for improved maize seed as well as a new classification need to be explored.

Keywords: maize breeding, maize seed, lowlands, community-based seed production, open pollinated varieties.

INTRODUCTION

Maize in the coastal lowlands of Kenya

Kenya's coastal province has a long history of economic activity, with a distinct differentiation by ethnic group. Swahili traders have been occupying the coastal towns for several centuries, while the nomadic pastoralists roamed the semi-arid hinterland. In between those two groups, the agriculturalists of the Mijikenda tribe settled in a band along the coast about 400 years ago (Waaijenberg, 1994). Until the 19th century, they lived in nine *makaya* or fortified villages on top of wooded hilltops, growing sorghum, millets, and cowpea. During the 19th century, they left the *makaya* to settle on the uplands and plateaus, and adopted maize, rice, and cassava as staple foods. At the end of the 20th century, the Mijikenda were still the most important group within the agriculturalists. Although agriculture is still their main economic activity, it has changed drastically: maize has become the dominant staple while sorghum and millets have basically disappeared from the area (Waaijenberg, 1994).

Maize was probably introduced into East Africa by Portuguese slave traders (Dowswell et al. 1996, p. 18). The first varieties were flints from the carribean, and white dent varieties were only introduced much later. The main agrocecological zone where maize is currently grown is the lowland tropics (Hassan, 1998), a band of about 80 km along the coast. At present, the province produces more than 50,000 tons of maize on slightly less than 50,000 ha, or an average yield of 1.06 tons/ha (Ministry of Agriculture, unpublished data from 1998, 1999 and 2000). More than 90% of the production is in the first season. The region faces a large deficit: while maize is the major staple food, the maize production for its 2.5 million inhabitants (Central Bureau of Statistics, 2001) amounts to only 20 kg/person. The average maize food consumption per person for Kenya is estimated at 94 kg/person (Pingali, 2001).

Maize improvement work started in 1952, but was not very successful in the early years (Wekesa et al., 2003b). In 1974, the broad-based Coast Composite was released, developed from introduced tropical material with tolerance/resistance to maize rust. In 1989, the first hybrid for the lowlands was released: Pwani hybrid 1(PH1), a variety with short maturity (105 days) and higher yield potential than Coast Composite (Table 2). A second hybrid with a higher yield potential, Pwani hybrid 4 (PH4), followed in 1995. Despite these releases, average maize yields did not increase much and are substantially lower than the national average of 1.5 kg/ha.

Adoption of the improved varieties at the coast has been low. A farmer survey from 1998 revealed that 70% of farmers still grew the local varieties, while 22% planted Coast Composite and 21% PH1 (Wekesa et al., 2003b). During Participatory Rural Appraisals (PRA), farmers indicated that the local varieties are hardier and they store well. The improved varieties don't store as well, while the seed is expensive and often of poor quality. The major constraints farmers perceive in maize production are ranked as field pests, cash constraints, wildlife, and storage pests (Wekesa et al., 2003a).

Liberalizing the Kenyan maize seed system.

Up until the early 90s, Kenya followed the classical African seed model, dominated by parastatals. New varieties were developed by public research institutes, now based at

Table 1. Description of coast maize varieties used in community seed project.

	Mungindo	**Mengawa**	**Coast Composite**
Tassels	Tassels: 70% green, 30% purple, Branches: open, others erect, Anthers: yellow. *pollen shed:* 53 days from germination.	Tassels are 70% purple and 30% green. Branches are open and others erect. Anthers: purple. *pollen shed* : 53 days from germination	Tassels 90% green, 10% purple. Branches: open, others erect. Anthers: yellow. *pollen shed* : 54 days from germination.
Leaves	Leaves: green color, fairly wide. A few plants are purple and have purple purple veins. Resistant to foliar diseases like GLS, Maydis blight, Polysosora rust and MSV.	Leaves: green color, fairly wide. A few plants are purple and have purple purple veins. Resistant to foliar diseases like GLS, Maydis blight, Polysosora rust and MSV	Leaves: green color, fairly wide. A few plants are purple and have purple purple veins. Resistant to foliar diseases like GLS, Maydis blight, Polysosora rust and MSV
Stem	Stems: cylindrical and predominantly green, others purple. Plant height: about 220cm.	Stems: cylindrical and predominantly purple, others green. Plant height: about 210cm.	Stems: cylindrical and predominantly green, others purple. Plant height: about 230cm.
Ears	Ear placement: about 120cm. Silking: 55 days from germination. Ears: cylindrical with 12 – 16 rows, predominantly straight.	Ear placement: about 110cm. Silking: 55 days from germination. Ears: cylindrical with 12 – 16 rows, predominantly straight.	Ear placement: about 130cm. Silking: in 55 days from germination. Ears: cylindrical and conical with 12-18 rows, predominantly straight.
Grain	Kernels: white a light yellow background, some purple kernels, shiny flint	Kernels: white, shiny flint	Kernels: white a light yellow background, shiny flint.
Maturity	110 days	110 days	140 days

Table 2. Results of the Community Seed Production project

Site	**Area (ha)**	**Seed production (tons)**	**Yield (tons/ha)**	**Variety**	**Remarks**
Mwanamwinga (Mtsengo)	1.5	2	1.33	CC	
Mwamamwinga (Kinarani)	0.5	0.4	0.8	CC	
Mtepeni	0.5	0.4	0.8	CC	
Ribe, farm 1	0.25	0.15	0.6	Mungindo	Because of rodents, replanting was done with these local varieties
Ribe, farm 2	0.25	0.15	0.6	Mengawa	
Kikoneni	1	0.9	0.9	CC	Due to high temperature, rainfall, and humidity, maize rust and maize blight, there was poor germination
Total	4	4	1.0		

the Kenya Agriculture Research Institute (KARI), while seed production was handled by the Kenya Seed Company (KSC), a privately structured company with a majority share owned by the government. Quality control was performed by a seed unit within KARI, extension of new technologies was in the hands of the Ministry of Agriculture, and seed was distributed through the retail network of the Kenyan Farmers Association (KFA). At the coast, the system released the three varieties described above, with mixed success. During the 1990s, however, the donor community (driven by the World Bank) saw the heavy state involvement as an impediment to the development of efficient input and output markets for agriculture, and raising productivity. Markets were liberalized in many countries, increasing efficiency and availability of technology to farmers (Gisselquist and Grether, 2000; Pray et al., 2001).

In the evolution of maize seed industries around the world a life-cycle can be recognized with several stylized stages (Morris et al., 1998). In the pre-industrial stage, farmers select and grow their own seed, which consist only of local OPVs. Individual farmers are the dominant players, although some exchanges between neighbors and family members occur. In the emerging stage, the advantages of specialized institutions such as research organizations is recognized, but the market is still too limited for commercial seed companies. Therefore, the state dominates in this phase, and the varieties produced are mostly OPVs. In the expansion stage, the private sector, i.e. the seed companies, gradually take over seed production and dissemination, thereby switching to the more lucrative hybrid varieties. Finally, in the maturity stage, seed companies also take on research and development of their own varieties. Part of this development, however, depends on hybrid seed sales to cover research costs.

It is more and more accepted that agricultural input markets, in particular the maize seed market, need to be liberalized to allow the private sector to play its role and help move the industry swiftly through the different stages. However, liberalization is a necessary, but not a sufficient condition. For the private sector to operate, it also needs a welcoming and enabling environment (Tripp, 2003). The supply side needs a proper legal framework and regulatory environment. For efficient distribution, proper systems need to be in place, as well as transport infrastructure to decrease the transaction costs (Tripp and Rohrbach, 2001). From the demand side, farmers will use improved seed if it is sold at a fair price, at the appropriate time, at a convenient place, in the quantities needed and in manageable units (Douglas, 1980).

In Kenya, the high potential zones, in particular mid-altitudes, transitional zone and highlands, are very interesting to the seed industry: the large majority of maize is produced here and a large proportion of farmers have adopted new varieties. The liberalization led to the opening of seed markets, with international entries such as Pioneer (US) and Pannar (South Africa) who successfully introduced their materials for the mid-altitudes and transitional zones. In the highlands, however, KSC remained its quasi-monopoly, largely because its competitors lack good late maturing germplasm (Nambiro et al., 2003). Following the live cycle model, KSC has grown more independent from KARI, and developed its own late maturing varieties.

Although agricultural policies are necessarily the same for the whole country, the development of the seed markets is not necessarily homogenous and a country can be at different stages in different areas. Agroecological conditions, market conditions, infrastructure and other aspects can vary tremendously, and influence the stage. As can be expected, new companies were not immediately interested in bringing in new materials for the low potential zones, in particular the semi-arid and lowland tropics. For the semi-arid tropics, KSC produces two open pollinated varieties developed by KARI, but is sells them at the same price of hybrid seed, citing higher transport costs. Some local companies are also producing the same OPVs. Liberalization has increased the number of stockiest in the area, but due to low yield and high costs, seed sales have stagnated. Many NGOs and projects have also started activities in seed production and dissemination, although these activities are not sustainable and depend on external funding (Muhammad et al., 2003). The lowlands, however, have not benefited from these developments. On the contrary, KSC stopped producing its only lowland OPV, Coast Composite, to focus solely on its two hybrids, and no new companies operating here.

Developing alternative seed systems for the low land areas.

The lowland tropic grows about 50,000 ha of maize a year, which is considered just at the limit to justify a breeding program. It is much smaller than any of the other agroecological zones of Kenya, and also at a substantial distance from these other zones. Because of its proximity to the Indian Ocean with its busy trading routes it had, on the other hand, much more access to a wide range of varieties imported by traders. Farmers had many opportunities to try out and adapt these varieties, leading to a range of locally adapted varieties, very popular with farmers. Most farmers select their own seed, but there is also an informal seed market for local varieties, which has not gone through the formal certification process. There is also a market for recycled OPV seed. Some farmers sell their surplus seed to neighboring farmers (revealed during PRAs, Wekesa et al., 2003a), and many stockists sell seed from local varieties (stockist survey of 2000, unpublished data).

Although the private sector stopped providing OPVs for the region, their production is a fairly straightforward process. Moreover, they can be reproduced by farmers and distributed farmer-to-farmer for several cycles without substantial loss of yield potential or good agronomic characteristics. If this seed is produced in the farmers' environment in collaboration with the farmer, and made available to them at a reasonable cost, farmers are likely to buy and grow those varieties. Under these circumstances, and using cheap packaging methods, the cost of seed will be generally lower than the current commercial seed prices. Since farmers are willing to adopt new cultivars when they offer tangible benefits and seed is reasonably priced (Dowswell *et al.,* 1996), this would allow them to substantially increase their production. Seed availability at the right time and cost has been a hindrance to the adoption of improved varieties in the region.

OBJECTIVES

Therefore, a seed production activity was started on an experimental basis in the coastal region of Kenya, to bring affordable maize seed within easy reach of the farmers, as an alternative to commercial seed production. This activity was carried out using a group approach more than individual, where farmers were involved from land preparation up to packaging and seed distribution. Three preferred open pollinated varieties were included in the project plan and planted according to where demand was expected to be highest.

This pilot project analyzed the potential of community seed production. It aims to study how improved seed of preferred open pollinated varieties can be availed in the region at a fair price, appropriate time and convenient place in the quantities needed and in manageable units. It also studies the transfer of recommended management package of the maize crop from planting to storage of harvested produce, and introduction of maize seed production in the area as an enterprise.

MATERIALS AND METHODS

The project's initial goal was to produce only Coast Composite, the popular OPV whose production was discontinued by KSC. The Intellectual Property Rights (IPR) of this variety belong to KARI, who developed it in the early 1970s. The project followed a two-stage approach: first pre-basic and basic seed was produced on-station, followed by mass production by farmers.

In the first stage (long rains of 2000), the pre-basic and basic seed of Coast Composites were produced on plots of 0.25 hectares each on-station during the long rains. The selection pressure was higher for the basic seed production than during the commercial seed production. The purpose of producing pre-basic seed is mainly to rejuvenate, increase the quantity of seed and store it for later use. Its selection criteria or higher than for the other types. In the pre-basic seed plot, 500 ears were selected according to the selection criteria mentioned below. These were then harvested and preserved separately. Basic seed (American terminology adopted by Kenya, corresponds to the British term "foundation seed") is used to produce certified or commercial seed (Government of Kenya, 1999, p. 63), and is subject to less selection pressure. The ears from the basic seed plot were threshed and seed was bulked. This was to be used by the following seasons' commercial seed producers. All activities in the first stage were executed by KARI's scientific and technical staff in Mtwapa.

In the second stage (long rains of 2001), basic seed was used to produce commercial seed in five different sites: four in Kilifi district and one in Kwale district (Table 2). Farmer selection, characterization, adoption and impact monitoring was carried out by the socio-economist, using PRA techniques. The selected farmers were already selling seed of advanced generations of the commercial PH1, PH4, Coast Composite and the local varieties in the area. For this project, a total of 4 ha was planted. This was more than initially planned, due to the great interest in the activity as expressed during the PRAs. However, in one farm at Ribe (Kilifi), the planted seed was eaten by rodents and replaced by local varieties Mengawa and Mungindo. These varieties had been subjected to some genetic improvement on-station, and sufficient seed is stored and maintained in the KARI station of Mtwapa. The fieldwork was done by farmers, with technical support and backstopping by KARI scientific staff and local extension agents.

In total, three varieties were planted on 4 ha on 6 farms: 3.5 ha in Coast Composite, 0.25 ha to Mungindo and 0.25 to Mengawa. The production, management and selection criteria were the same in all the activities only that selection pressure was low.

Coast Composite is the most popular open pollinated improved variety at the coast. It is of medium maturity (140 days), white and flint (Table 3). Mungindo and Mengawa are popular local varieties, also flint. Both are white but Mengawa has a purple cob, husk and tassle, and has some deep purple grains on most cobs. These local varieties are early to medium maturing (110 days), they are more resistant to field and storage pests, relatively more resistant to MSV, tropical rust, and blights. The three varieties, when roasted, taste sweeter than commercial hybrids.

On the station, and in Ribe and Mtepeni, land was prepared using tractor drawn implements, consisting of a disc harrow followed by a disc plough. Animal traction was used on the other sites. Planting was done by hand at all sites, with a spacing of 75 cm between rows and 25 cm between hills. Two seeds were planted but were thinned back to one plant with compensation, to generate a plant density of 65,000 plants/ha. Soil pest control was done using Furadan 3G at the rate of 2.5g per hill.

Two types of fertilizer were used: diammonium phosphate (DAP) was applied one week after germination at the rate of 100 kg/ha, and calcium ammonium nitrate (CAN) was applied in 2 doses of 150kg/ha: at three weeks and at seven weeks after germination (after the first and second weeding). Thinning was done three weeks after germination, allowing two plants per hill in the event of complete failure of a hill. Stem borers were controlled using Bulldock 0.5% G (Beta cyfluthrin 0.5%g/kg), applying a pinch or a brief shake into each maize whorl (12-16 kg/ha) twice: at three and seven weeks after germination. Weeding was done three times in each site: using animal traction in Mtsengo and Kikoneni, by hand at all other sites.

Harvesting was done by hand, carefully picking the selected ears according to the selection criteria mentioned below. The plants to be harvested for seed had been left with their tassels on, while the rejected plants had been cut above the ear. Five hundred ears were selected to form foundation seed for each location. Threshing was done by hand. The 500 seed ears per site were preserved separately while the commercial seed ears were threshed in bulk in both cases leaving about 2 cm to the top and bottom of the ear. These materials were sun dried to moisture content of 13-15 % on average. All seed was treated using Actellic Super against storage pests. It was viewed necessary to use non-toxic drugs to human beings at this level of seed production.

Selection criteria used included maturity, vigor, plant and ear height, diseases, husk cover, lodging rot, and seed texture. Plants that flowered 55-60 days after germination were selected for seed production. Very early and late plants were cut above the ears and rejected. Vigorous plants were favored in the selection process, and plants with heights of 2.8 to 3.2m with medium ear placement were selected. Very tall and short plants with high ear placement were rejected. Plants were also selected for resistance to MSV, the disease of major concern in the region. Other diseases like *Puccinia polysora* rust and *Descheria maydis* affect the crop at an advanced stage and can be controlled with fungicides. All ears that had bare tips or poor husk cover were selected against, and tight husks and droopy ears were favored. Plants with broken stalks, lodged roots, and rotten ears were discarded. Rotten ears were equally discarded. Finally, ears with very dent texture were rejected.

Initially, the project intended to pack seed in 1 kg paper bags for distribution and sale. However, once farmers were aware seed was being produced, they came to buy in bulk on the spot. Since marketing and sales were not a problem, packaging was not necessary.

RESULTS

At the KARI station in Mtwapa, pre-basic and basic seed of coast composite was produced that had been improved on-station. For pre-basic seed 500 ears of each variety were selected, harvested and preserved. Three other plots for basic seed of the three varieties were harvested and 50 kg of basic seed was preserved. The materials selected were mainly flint.

On farm, 2.8 tons of seed were produced on 4 ha. Apart from this commercial seed, 500 plants in each site were selected for pre-basic seed, and stored at the Mtwapa KARI station. Moreover, grain from the rejected plants was consumed as food. Only the commercial seed was sold, at 100 KSh/kg. This was substantially cheaper than the going price of hybrids at 140 Ksh/kg, which created a large demand. All seed was sold on the spot, immediately after harvest, in bulk. Demand was larger than supply, and farmers expressed an interest in continuing this activity. The profits from the sales went to the seed producers. Inputs such as fertilizer and pesticides were provided by the project.

No detailed records on inputs and outputs were kept, preventing a thorough economic analysis. Still, the available cost and revenue data provide some useful insights. The total

Table 3. Economic analysis of community seed production

	Outputs and production factors	Units	Value[a] (Coast, 2001)	Value[b] (Drylands, 1998)
Revenue	Seed production	kg	4,000	
	Area used	ha	4	
	Yield obtained	kg/ha	1000	1,513
	Sales price for seed	KSh/kg	100	36.5
	Total revenue of project	Ksh	400,000	
	Revenue/ha	Ksh/ha	100,000	55,253
Costs	Fertilizer: Diammonium phosphate (DAP) and Calcium Ammonium Nitrate (CAN)	Ksh/ha	5,900	4,375
	Pestides (only Bulldock at the coast)	Ksh/ha	1,120	2,298
	Weeding	Ksh/ha	300	
	Land preparation	Ksh/ha	1,500	
	Labor	Ksh/ha		914
	Total production costs per ha	Ksh/ha	8,820	8,867
	Total production cost/kg of seed	Ksh/ha	12.6	5.9
	Treatment for storage (0.55 g/actellic/kg)	Ksh/kg	0.32	
	Grain price (Mombassa, average 2001 price)	Ksh/kg	13	
Cost	Total project cost	Ksh	260,000	

a Estimation based on observations during the project
b Muhammad et al., 2003., adjusted for an estimated 11% inflation, as calculated from the Consumer Price Index, (Central Bureau of Statistics, 2002)

external financing of the project was 260,000 Ksh, mostly for agricultural inputs and travel allowances. The project did not provide for salaries of project collaborators or labor for the farmers. In total, 2800 kg of seed was produced, and it was sold at 100 Ksh/kg, a total of 280,000 Ksh. Therefore, if the real costs of labor and salaries would be included in the analysis, total costs would clearly be larger than the revenues.

At the farmer's level, total costs of the seed production amount to 8,820 KSh/. This is very similar to the seed production cost for OPV in a project in the drylands, estimated at 8,867 (Muhammad et al., 2003). Seed production yields at the coast, however, were only 700 kg/ha so the production cost amounts to 12.6 Ksh/kg, versus only 5.9 in the drylands. With a price of 100 KSh/kg at the coast (as compared to 13 KSh/kg for grain), the activity is economically feasible. In the drylands, the sales price of improved maize seed was only 36.5 KSh/kg, but because of the higher yield the activity was still economically feasible.

DISCUSSION AND CONCLUSIONS

The project succeeded in its goal, the production of improved maize seed at the community level, even producing more than the planned 3 ha. The three objectives were also met despite the rodent problem at Ribe. Improved maize seed of preferred open pollinated varieties in the area were availed at a fair price, appropriate time and convenient place in the quantities needed and in manageable units. The improved versions of the preferred maize seed in the area were produced within the farmers' environment, and collaboratively with the farmers, and then made available to them at a reasonable price. In the next season, it can be expected that the farmers will plant an increased amount of land to varieties with a good yield potential and hence increase their production. Farmers were willing to adopt new cultivars when they were offered tangible benefits and reasonably priced seed. This exercise of working collaboratively with farmers introduced maize seed production in the area as an enterprise. The seed produced from varieties within the target ecology will provide locally adapted improved varieties at an acceptable price.

In the next cycle of seed production, KEPHIS will be involved in the inspection of seed to certify seed quality at the community level. Certified basic seed of the three varieties will be sold to any interested seed producer in the region to be able to make the process sustainable. With the realization that seed is being sold whether certified or not among farmers, there is a need to train local seed producers on issues of seed production and storage to ensure seed quality. Future seed producers should consist of progressive, innovative and capable producers whose farm location provides good isolation to ensure seed purity.

At its current level of benefits and costs, the project is not cost efficient. The purpose of public research is to produce technologies that are public goods for use by farmers and consumers. The public sector should focus on those activities, which are not interesting to the private sector, especially those that are imperfect private goods. OPV seed falls in this category: once sold, the farmer can reproduce the seed and pass it on to other farmers. The seed company cannot prevent recycling of this seed in future years or by other farmers. Still, research funds should be allocated where the return is the highest. The experience of this project shows that farmers are able and willing to produce improved OPV seed locally at 100 KSh/kg. To make such a project more cost effective, costs need to be cut and more seed need to be produced to reach more farmers. Given the large demand for improved OPV seed, the project should also be able to recover more costs by charging for the basic seed as well as the agricultural inputs.

On the policy side, alternative seed production systems need to be explored that respond more to the needs and current practices of farmers. Currently, requirements for the production of certified seed are prohibitively expensive for the small-scale producer, and the market is too small for a large-scale producer. Consequently, improved OPV maize seed is no longer produced at the coast, contrary to popular demand. Responding to this market failure, farmers do produce and sell seed through informal channels. It should therefore be analyzed how these informal channels connected to formal research, using improved material owned by the regional maize program (such as Coast Composite) or by improving local varieties as in this project. The establishment of a new seed category, below the requirements of certified seed, but using germplasm and technical support from the regional maize research program, seems promising. In order to develop a proper category, the benefits and costs of alternative regimes need to be analyzed. In particular, the cost of production of community and individual seed production needs to be understood better, as well as the demand for seed of improved varieties.

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