Adoption of Maize Seed and Fertilizer Technologies in **Embu District, Kenya**

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KARI

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International Maize and Wheat Improvement Center

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Abstract: This study reviews socioeconomic and technical factors that affect the adoption of improved maize and fertilizer in the Embu District, Kenya and the role of credit in both. A total of 127 farmers (82 adopters and 45 non-adopters) were interviewed for the study during the long and short rainy seasons in 1998 in the Nembure, Runyenjes, and Kieni Divisions in Embu District. Most farmers in the study area used basal fertilizer. However, the use of fertilizer was below recommended levels. More adopters used hired labor and had greater access to credit and extension services than non-adopters. The Pioneer H3253 variety and 2-kg seed packages were found to be most popular among adopters. Agroecological zones, gender, manure use, hiring of labor, and extension services were found to be statistically significant in explaining adoption of improved varieties. Similarly, agroecological zone, gender, manure use, hiring of labor, and extension services were important in explaining the amounts of basal fertilizers farmers used.

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Acronyms and Abbreviations

ASN	Ammonium Sulphate Nitrate
CAN	Calcium Ammonium Nitrate
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
DAP	Di-Ammonium Phosphate
EU	European Union
KIT	Koninklijk Instituut voor de Tropen (Royal Tropical Institute)
KSh	Kenyan shilling
masl	Meters above sea level
MOA	Ministry of Agriculture
NGO	Non-governmental organization
OPV	Open-pollinated variety
PHB	Pioneer hybrid
RRC	Regional Research Center
SPSS	Statistical Package for the Social Sciences
TSP	Triple Super Phosphate

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Executive Summary

Maize is a major food crop in Kenya and dominates all food security considerations in the country. It accounts for more than 20% of all agricultural production and 25% of agricultural employment. Smallholder farmers contribute more than 70% of the country's maize. Commercial farmers also contribute a significant portion of commercial maize. Because of the importance of maize to food security, the Kenyan Government has supported a maize breeding program that has released more than 20 modern maize varieties since 1955. The adoption of these improved maize varieties and use of inorganic fertilizer by large-scale farmers in high potential areas were major factors for increased yield growth between 1963 and 1974. While adoption rates by small-scale farmers in high potential areas equaled those of large-scale farmers between 1975-1983, yield gains were smaller – many small-scale farmers adopted new varieties but not fertilizer technologies. Between 1985 and 1991, improved seed was adopted in low potential areas, but fertilizer use remained low.

This study was undertaken to identify socioeconomic and technical factors affecting the adoption of improved maize seed and fertilizer use, and also to determine the role of credit in both. The information will assist maize research and extension specialists to develop suitable technologies for farmers in different environments and from different socioeconomic backgrounds. The analysis will also enable policy makers to identify policy and institutional factors that can contribute to increased adoption of high-yielding maize technologies.

Three maize growing divisions in the Embu District, Kenya—Nembure, Runyenjes, and Kieni—were purposively selected for the study. Embu District was selected because it is representative of maize growing areas in the region. The survey was conducted in Upper Midland 2 and 3 zones (Jaetzold and Schmidt 1983), where land use is dominated by coffee/dairy land use systems.

The study covered both the long rains lasting from March through June and short rains from October to December**.** One hundred and twenty-seven farmers were randomly selected and interviewed. Using a structured questionnaire, data was collected on farmer and farm attributes and institutional structure. Adopters of certified maize were defined as farmers who planted certified maize for two consecutive seasons in 1998 and non-adopters were defined as farmers who planted local recycled hybrid seeds or recycled seeds of open-pollinated varieties for more than three seasons. A comparative analysis was done between adopters and non-adopters of improved maize seed. Since productivity gains in maize seed depend on simultaneous use of other inputs, particularly fertilizer, the level of fertilizer used by adopters and non-adopters was also determined. Logit and linear models were used to analyze factors affecting adoption of improved maize seed and quantity of fertilizer, respectively.

Nearly all farmers (about 98% of adopters and non-adopters in the long rains and 96% and 88% of adopters and non-adopters in the short rains, respectively) used basal fertilizer irrespective of whether they planted certified maize seed. The use of top dress fertilizer in the long rains was more common among adopters (44%) than non-adopters (17%). Compound fertilizer (23:23:0) was the main basal fertilizer adopters (52% and 55% of responses in the long and short rains, respectively) and non-adopters used (56% and 64% in the long and short rains, respectively). Calcium ammonium nitrate was the main top dress fertilizer adopters (100% and 96% in the long rains and short rains, respectively) and non-adopters used (88% in both seasons). Most maize farmers applied much less than the optimal level of fertilizer (50 kg/ha N). Adopters applied 35 kg/ha N in the long and short rains, while non-adopters applied 31- and 32 kg/ha N in the long and short rains, respectively.

More adopters (83%) than non-adopters (69%) hired labor for farm operations. Significantly more adopters (78%) than non-adopters (64%) obtained formal credit from co-operative societies in the form of seed and fertilizer ($p<0.1$). About 66% and 49% of adopters used credit to purchase fertilizer for coffee or maize, respectively, while 56% and 44% of non-adopters did so. The average amount of credit was Ksh 6,802 (US$1=Ksh 60,263 (1998)) for adopters and Ksh 3,613 for non-adopters. To get credit from the cooperative society, farmers had to deliver the coffee crop. The main reason cited by adopters for not using credit was availability of capital (29%). Twenty-one percent of adopters said that it did not pay to use credit in maize production. For non-adopters, the main constraint was lack of collateral (71.4%) (in the form of coffee delivered to coffee co-operative societies).

More adopters (90%) than non-adopters (76%) had access to extension. The main source of extension was the Ministry of Agriculture (83% of 64 responses by adopters and 74% of 28 responses by non-adopters). More adopters (81%) than non-adopters (69%) received advice on improved maize production. However, this difference was not significant. The main type of extension advice was on fertilizer use (52% of 82 responses for adopters and 50% of 44 responses for non-adopters).

Agroecological zones, gender, manure use, hiring of labor, and extension were statistically significant in explaining adoption of improved maize variety. Other variables—age and education of household head, farm size, credit, years of formal education, area under coffee, and farmer group membership— which were expected to influence adoption and fertilizer use were not significant (at 10% or lower probability level) in explaining adoption decisions. Likewise, agroecological zone, gender, manure use, hiring of labor, and extension were important variables in explaining the amounts of basal fertilizers farmers applied.

Most adopters of certified seed preferred Pioneer H3253 in 1998. While there was a marked increase in the use of Pioneer H3253 between 1996 and 1998, the proportion of farmers using older hybrid varieties, H511 and H512, decreased in the same period. Adopters preferred the Pioneer hybrid for its high yield and early maturity, despite its high price, poor storage, and root lodging. Other valued traits were pest and drought tolerance, large grains, taste, good threshing quality, and ease of cooking. Most adopters preferred the smaller 2-kg seed package because it was affordable and sufficient for their plots of maize.

For most farmers the high price of improved maize seed was the major constraint for adoption (96% of adopters and 88% of non-adopters). Other constraints mentioned were the low selling price of maize (20% of adopters and 18% of non-adopters) and lack of credit (12% of adopters and 18% of non-adopters).

The study shows that many attributes are taken into consideration in variety selection. In addition, farmers also mentioned that they used recycled seed because of the high price of improved maize and because they find that there is little difference between yields in improved and recycled seed. A greater focus on farmer participatory breeding will help incorporate farmers' assessments of maize varieties in the research process. Further studies on the economics of seed recycling will help in greater understanding of farmers' use of recycled seed. The packaging of maize seed in small and more affordable packages such as the 2-kg bags will also help increase adoption of certified maize.

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James O. Ouma, Festus M. Murithi, Hugo Verkuijl, Wilfred Mwangi, Macharia Gethi, and Hugo De Groote

Introduction

Agriculture is the main economic sector in Kenya and contributes significantly to national development. It is a sector that receives high priority and attention from the Kenyan Government. In its Sessional Policy Paper No. 1 on Economic Management for Renewed Growth, the Kenyan Government stated that self-sufficiency in the production of agricultural products such as maize, beans, and vegetables is a key strategy for sound economic management and renewed growth for the country. For the agricultural sector to play this central role in a sustainable way, rapid growth in output and productivity is critical. It is widely recognized that the sustained flow and use of improved agricultural technologies is key to increased growth and agricultural productivity.

Maize is a major food crop and dominates all national food security considerations in Kenya. The area under maize is estimated to be approximately 1.5 million hectares, and per capita consumption averages 103 kg/yr (Pingali 2001). Maize accounts for more than 20% of all agricultural production and 25% of agricultural employment. Smallholders produce about 70% of the nation's maize, although large-scale farmers also contribute a significant proportion of commercial maize production (GOK 1983). Because of the importance of maize to national food security, the government of Kenya has supported maize research since 1955, when a maize research program was started to increase maize production.

More than 20 modern maize hybrids and varieties have been released in the four decades since the program began. Large-scale farmers in high potential areas adopted the new hybrids (Gerhart 1975). About half of these farmers adopted improved seed and inorganic fertilizer use, which were major factors in the growth of maize yields between 1963 and 1974. Between 1975 and 1984, many smallholder farmers in high potential areas also adopted improved seed and eventually equaled adoption rates of large-scale farmers (Hassan and Karanja 1997). However, yield gains were smaller during this period for a number of reasons: many smallholders adopted improved seed but not fertilizer use, an unfavorable policy environment, and severe drought in 1979-80 and 1983-84. Between 1985 and 1991, improved seed was adopted in low potential areas, but fertilizer use remained low.

The average yield for maize in Kenya is about 1.5 t/ha (Pingali 2001). Most smallholders produced under 1 t/ha, well below the potential average of 4.7 t/ha (Hassan et al. 1998). In Embu District, the study area for this report, maize yield is estimated at 0.5 t/ha (Ministry of Agriculture 1998). Other studies (Murithi et al. 1994) estimated yields at 1.3 t/ha and 0.9 t/ha in the major (March to June) and minor (October to December) seasons, respectively. Studies (Matiri et al. 1996) conducted in the neighboring Meru District, concluded that many farmers adopted the recommended agricultural practices (time of planting, time and number of weeding, type of planting arrangement and spacing). Even though there were indications from the study that many farmers were also using hybrid seeds recommended by the national maize research program, the issue remained contentious because farmers regarded recycled seed from the previous harvest as improved seed as well. Fertilizer use was also far below recommended levels.

This study identifies constraints and potentials for higher yield gains in maize in the Embu District. More specifically, it examines maize farmers' circumstances and farming practices, identifies major socioeconomic and technical factors that influence adoption of improved maize seed and fertilizer technologies, and determines the role of credit in the study area. In particular, it analyses determinants of recent patterns of maize technology adoption and sources of maize productivity gains. This information will assist maize research and extension to develop suitable technologies and target them appropriately to farmers in different environments and from different socioeconomic domains. The analysis will also enable policy makers to identify policy and institutional factors that can contribute to increased adoption of high yielding maize technologies.

The Study Area

Embu District has a diversity of agroecological conditions ranging from high altitude dairy or temperate vegetables zone (UM1) to very dry lowland livestock-millet zone (L5). Ten major agroecological zones covering 81% of agricultural land have been identified in Embu. The District has five major soil types, *nitosols, andosols, vertisols, ferrosols, and cambisols*. The soils and agroecology of the area are greatly influenced by Mount Kenya and Nyandarua ranges.

Embu District covers an area of 819 km^2 and has a population of more than 278,000 (Table 1). Excluding 210 km^2 of Mount Kenya, this translates into a high population density of 456 people per km^2. The district is divided into five administrative divisions: Central, Kyeni, Nembure, Runyenjes, and Manyatta (Figure 1). These five divisions are sub-divided into 15 locations and 52 sub-locations with about 45,000 farm families.

Table 1. Administrative division and population, Embu District, Kenya.

Division	Total population	Households (no.)	Area (km^2)	Population density (persons / km^2)
Central	52,466	14,726	70.6	743
Kyeni	48,385	10,441	104.9	461
Manyatta	71,332	15,523	197.1	666
Nembure	41,590	8,976	88.1	472
Runyenjes	64,111	13,981	149.0	432
Mt Kenya Forest	332	246	210.2	2
Total	**278,216**	**63,893**	**819.0**	**456†**

Source: Central Bureau of Statistics (2001)
Note: †Excluding Mount Kenya Forest

Kyeni, Nembure, and Runyenjes are the three major maize producing Divisions with a mixed farming system. Maize, beans, mangoes, pawpaw, pigeon peas, cowpeas, coffee, cotton, avocado, bananas, greengrams, and sunflower are the main crops. Maize and beans are grown as either intercrops or monocrops. The average farm size ranges between 2-2.8 ha per household.

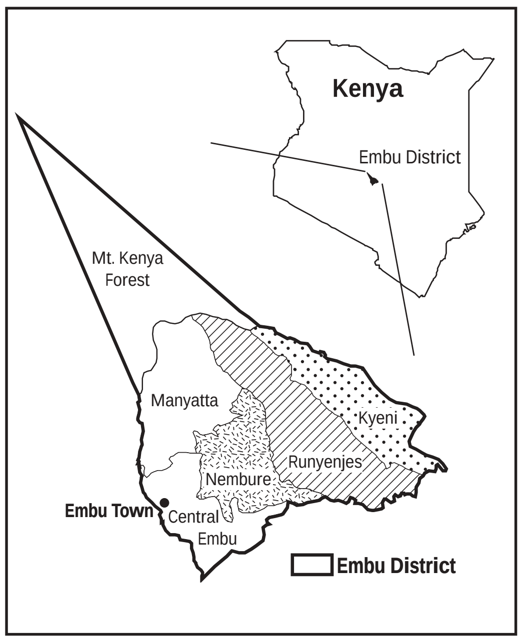

Figure 1. Embu District Divisions, Kenya.

Kyeni Division was carved out of Runyenjes's Division in 1996. It borders the Meru South District to the east, Runyenyes Division to the west, Mbeere District to the south and Mount Kenya forest to the north. It lies between 1,000-1,700 masl and covers 104.9 km^2, of which 78.62 km^2 is arable land. Kyeni has three administrative locations – Kyeni North, Kyeni, and Karurumo. Each administrative location has 6-10 sub-locations. The average family size is six and the average farm size is 0.8-2.4 ha in the upper and middle zones, respectively. The rainfall is bimodal: the October-November short rains provide between 1,200 to 1,850 mm and April to May long rains between 850 to 1,850 mm. Soils are well drained and mostly *nitrosols*.

The Runyenje Division lies between 1,200-2,070 masl. It covers 149 km^2, out of which 96.26 km^2 is arable land. The Division has three administrative locations and sub-locations. The estimated population is 64,111 and average farmholding is 0.4-0.8 ha. The annual average rainfall is between 1,000-2,000 mm and distribution is bimodal. The long rains fall in March to April and October to December.

Nembure lies between 1,000-1,500 masl. It covers an area of 88 km^2, of which 65 km^2 is arable land. Nembure has three administrative locations: Gaturi South, Kithimu, and Makengi. The estimated population is 41,590 and population density is 472 persons per km^2. The average annual rainfall ranges from 1,200 to 1,500 mm. Rainfall is bimodal and distributed in March/April (long rains) and October/November (short rains). Soils are fertile and well drained.

Methodology

Sampling Procedure

Embu District was chosen because it is representative of other Districts in the region where maize is a major crop. The District's proximity to the Regional Research Center in Embu also ensured quality data and made data collection easy. Three of the five Divisions mentioned above – Nembure, Runyenjes, and Kyeni – were purposively selected. The survey was conducted in the main maize growing areas of the three Divisions, classified as Upper Midland 2 (UM2) and Upper Midland 3 (UM3) (Jaetzold and Schmidt 1983), that together are dominated by the coffee/dairy land use systems.

Villages were randomly selected from four sub-locations selected from six maize growing areas (two from each Division). One hundred and twenty-seven farmers were interviewed – 82 adopters and 45 non-adopters. Data was collected on farmer and farm characteristics and institutional factors using a structured questionnaire. Adopters of certified maize seed were defined as farmers who planted certified maize seed for two consecutive seasons in 1998, and non-adopters were defined as farmers who planted local seed, recycled seed of hybrids or, in the case of open-pollinated varieties (OPVs), recycled seed for more than three seasons.

Model Specification

In adoption studies, responses to a question such as whether a technology was adopted could be yes or no, a typical case of a qualitative dichotomous variable. However, factors (independent variables) that affect a given maize technology adoption can be expressed both qualitatively and quantitatively. When the dependent variable is continuous, linear models such as ordinary least squares (OLS) are used to show the effects of independent variables on the dependent variable. However, when the dependent variable is dichotomous, the use of linear probability models is a major problem: the predicted value can fall outside the relevant range of zero-to-one probability values. To overcome this problem, logit or probit models have been recommended (Gujarati 1988).

Logit and probit models have been widely used in different adoption studies (for example, Yahanse et al. 1990; Polson and Spencer 1991; D'Souza, Cyphers, and Phipps 1993; Hussain, Byerlee, and Heisey 1998; Salalsya et al. 1996; Chilot, Shapiro, and Demeke 1996). These models not only help assess various factors that affect adoption of a given technology, but also provide predicted probabilities of adoption. For example, they can be used to indicate how the likelihood of a farmer adopting a particular technology changes according to his or her level of education, keeping all other factors constant.

Generally, adoption studies consider many factors to explain farmers' adoption decisions. In Embu District, it was hypothesized that a farmer's decision to use or not use a given maize technology is influenced by the characteristics of the household head (gender, age, and formal education), farm size, manure use, use of credit, extension advice, labor, cash crop, and farmer group membership.

Detailed discussion of how some of these factors might influence technology adoption is found in CIMMYT (1993). The empirical model for the two technologies is specified as follows:

$$\mathbf{TECH} = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + \ldots.\ B_{10}X_{10} + U$$

Where: TECH = adoption of improved maize varieties over the last two seasons, or quantity of fertilizer applied

X_1 = gender of household head
X_2 = farm uses organic manure (dummy variable)
X_3 = agroecological zone (UM2=1, UM3=0)
X_4 = farm uses hired labor (dummy variable)
X_5 = farmer received extension services (dummy variable)
X_6 = farmer uses credit (dummy variable)
X_7 = formal education of household head (years of schooling)
X_8 = age of household head (yr)
X_9 = farm size (acres)[†]
X_{10} = area under coffee (main cash crop) in acres
X_{11} = membership in farmer organization (dummy variable)
U = disturbance term; B_0 is the intercept and B_is are the coefficients of the independent variables

The working hypotheses for this report are:

- Use of organic manure: It is hypothesized that farmers who use cattle manure are more aware of the effect of fertilizers on crops and therefore better adopters of fertilizer technologies. This is a dummy variable (0=farmer did not use manure, 1=farmer used manure).
- Hired labor: It is hypothesized that there is a positive relation between adoption of improved maize technologies and hiring labor. This is a dummy variable (0=no use of hired labor, 1=use of hired labor).
- Contact with extension agent: Agricultural extension services are a major source of information in the study area and contact with extension agents increases a farmer's likelihood of adopting improved maize technologies. This is a dummy variable (0=farmer did not have extension contact, 1=farmer had extension contact).
- Credit: Access to credit increases the probability of adopting improved maize technologies. This is a dummy variable (0=no use of credit, 1=use of credit).
- Educated household head: A higher level of education increases a farmer's ability to obtain, process, and use adoption information of an improved maize variety or fertilizer. Education thus increases the probability of adopting improved maize technology.
- Farmer's age: It is hypothesized that with increasing age a farmer will be less likely to be aware of new maize varieties or fertilizer use. Younger farmers may have greater access to information because they have greater access to education, and thus will be more aware of technologies. Older farmers might not have access to this information.

[†] 1 acre = 0.405 ha

- Farm size: Farm size (acres) is an indicator of wealth (and perhaps a proxy for social status and influence within a community) and expected to be positively associated with the decision to adopt improved maize technologies.
- Area planted to coffee: Farmers with larger areas planted to coffee are better adopters of improved maize technologies. Coffee provides farmers with cash to buy inputs.
- Membership in an organization: Members of organizations (farmer groups, non-governmental organizations (NGOs)) have better access to information on improved maize technologies. Being a member of an organization is hypothesized to be positively associated with adoption of improved maize technologies. This is a dummy variable (0=farmer is not a member of an organization, 1=farmer is a member).

Maize Production Technology Recommendations

Maize Varieties

Table 2 shows different maize varieties that are recommended in the study area and their characteristics. As a significant amount of maize is planted in the coffee/dairy-based land use zone, it was selected as the study site. Even though maize is also planted in small amounts in the tea/dairy (lower highland 1 (LH1) – UM1) and maize/sunflower zones (upper midland 4 (UM4)), lower midland 3 (LM3) (UM4) and lower midland 4 (LM4), they were not included in the study.

Table 2. Recommended maize varieties, year of release, expected yields, and maturity period, RRC-Mandate Zone.

Land use system	Altitude	Variety	Year released	Maturity (days)	Yield potential (t/ha)
Tea Dairy Zone (LH1-UM1)	1,500-2,100 masl	H627	1996	180-240	3.6
		H626	1989	180-240	3.4
		H625	1981	180-240	2.8
		H614D	1986	165-210	2.7
Coffee Dairy Zone (UM2-UM3)	1,000-1,800 masl	H513	1996	120-150	1.8
		C5222	1996	120-150	1.8
		PAN 5195	1996	120-150	1.8
		PHB 3253	1996	120-150	1.8
		CG 4141	1996	105-130	1.4
		H512	1970	120-150	1.8
		H511	1968	120-140	1.5
		EMCO92SR	-	105-130	1.5
Maize Sunflower Zone (UM4/ LM3/LM4)	<1,800 masl	DH1 (dryland hybrid)	1996	90-120	1.2
		DH2	1996	90-120	1.2
		DLC1(Makueni)	1989	90-120	1.1
		KCB (Katumani)	1968	90-120	1.1
		CG4141	1996	110-120	1.2

Source: *Recommendation Guidelines for Crops, Soil Fertility and Livestock Management* (1998), RRC-Embu

Fertilizer and Manure Recommendations

The RRC-Embu guidelines recommend the use of compound fertilizers 20:20:20 or 23:23:0 at a rate of 50 kg N and 50 kg P_20_5 per ha at sowing in the coffee/dairy zones, top dress fertilizer applied at a maize height of 45 cm and at a rate of 50 kg N/ha, and farmyard manure at a rate of 5 t/ha at planting or before planting.

Demographic and Socioeconomic Characteristics

Tables 3 and 4 show demographic and socioeconomic characteristics of sampled households for adopters and non-adopters. About 4% of adopters and 11% of non-adopters were female-headed households. At least 58% of all farmers had primary education and above. Forty-six percent of farmers in UM2 were adopters and 20% were non-adopters. In UM3, 54% were adopters and 80% were non-adopters (Table 4). Farm households in UM2 are probably better resource endowed than those in UM3. More adopters (82.9%) hired labor compared to non-adopters (68.9%) (p<0.1).

Table 3. Demographic and socioeconomic characteristics of adopters and non-adopters of improved maize varieties, Embu District, Kenya.

	Adopters		Non-adopters		All farmers	
Characteristic	Mean	Standard deviation	Mean	Standard deviation	*t*-statistic	Mean
Age of household head (yrs.)	50.0	12.4	49.3	12.00	0.27 (NS)	49.8
Farm size (acres)†	3.7	2.3	3.8	3.6	0.18 (NS)	3.7
Area under coffee (acres)†	1.0	0.8	0.8	0.8	1.08 (NS)	0.9
Area under maize (acres)†	1.1	0.7	0.9	0.6	1.62 (NS)	1.0
Household size (no.)	8.2	3.3	7.0	2.8	2.10 (NS)	7.8

Note: NS= not significant. † 1 acre = 0.405 ha.

Table 4. Demographic and socioeconomic characteristics of adopters and non-adopters of improved maize, Embu District, Kenya.

Characteristic	Adopters (%)	Non-adopters (%)	χ^2	All (%)
Gender			2.7*	
Male	96.3	88.9		93.7
Female	3.7	11.1		6.3
Education			0.6 (NS)	
None	9	13.2		10.5
Primary	57.7	57.9		57.8
Secondary	26	28.9		27.0
Division			1.4 (NS)	
Kyeni	48.8	44.4		47.2
Runyenjes	28.0	37.8		31.5
Nembure	23.2	17.8		21.3
Zone			8.6***	
UM2	46.3	20		37.0
UM3	53.7	80		63.0
Use hired of labor			3.3***	
No	17.1	31.1		22.1
Yes	82.9	68.9		77.9

Note: NS= not significant; * = significant at p<0.1; ** = significant at p<0.05; *** = significant at p<0.01

Maize in the Farming System and Adoption of Varieties

As mentioned earlier, maize is a major food staple in the study area. A household without maize is termed food insecure. All sampled farmers grew maize. Other major food crops, in order of importance are beans, coffee, bananas, and Irish potatoes (see table in Annex).

Table 5 shows the main crops grown in the study area and their ranking by adopters and non-adopters according to their ability to meet subsistence or commercial needs. Overall, maize was the most important food crop for both groups of farmers, followed by beans, bananas, and Irish potatoes. Coffee was the main cash crop.

Table 5. Adopters and non-adopters ranking of crops grown according to subsistence and commercial needs, Embu District, Kenya.

	Adopters ranking of crops (%)					Overall percentage
Crops	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	of first 5 crops
Maize	25.6	61.0	11.0	1.2	-	98.8
Beans	4.9	26.8	57.3	4.9	-	93.9
Coffee	68.3	4.9	14.6	3.7	-	91.5
Banana	1.2	3.7	9.8	42.7	11.1	68.3
Mango	-	1.2	1.2	-	-	2.4
Avocado	-	1.2	-	-	1.2	2.4
Irish potato	-	-	3.7	13.4	8.6	25.6
Kale	-	-	-	-	-	-
Sweet potato	-	-	-	2.4	4.9	7.3
Arrow root	-	-	-	1.2	-	1.2
Cabbage	-	-	-	3.7	-	3.7
Macadamia				2.4	1.2	3.7
Tomato					1.2	3.7
	Non-adopters ranking of crops (%)					**Overall percentage**
Crops	**Rank 1**	**Rank 2**	**Rank 3**	**Rank 4**	**Rank 5**	**of first 5 crops**
Maize	33.3	51.1	11.1	6.7	2.2	100
Beans	4.4	35.6	55.6	2.2	-	97.8
Coffee	62.2	11.1	17.8	2.2	-	95.6
Banana	-	2.2	2.2	31.1	11.1	46.7
Mango	-	-	-	-	-	-
Avocado	-	-	-	2.2	-	2.2
Irish potato	-	-	8.9	20.0	4.4	33.3
Kale	-	-	-	4.4	-	4.4
Sweet potato	-	-	-	-	2.2	2.2
Arrow root	-	-	-	2.2	-	2.2
Cabbage	-	-	-	-	2.2	2.2
Macadamia	-	-	-	-	-	-
Tomato	-	-	-	-	2.2	2.2

Farmers Adoption and Disadoption of Improved Maize Seed

Maize Varieties (1996-1998)

Farmers were asked what was the most important maize variety they grew. Table 6 shows that Pioneer H3253 was the most important maize variety during the survey year. It was grown by 34% of farmers in both the short and long rains of 1998. While the use of Pioneer H3253 increased sharply between 1996 and 1998, the proportion of farmers using old hybrid varieties H511 and H512 decreased. This disadoption was attributed to low yields associated with old varieties, the availability of other promising new hybrids, and unavailability of seed. A considerable number of farmers also used recycled maize seed between 1996 and 1998 and cited high price of certified seed, coupled with lack of credit and low price of maize as the main limitation to using improved maize seed on a continuous basis.

Farmers indicated that the high price of improved maize seed was the major constraint for adoption (86% of adopters and 79% of non-adopters). Other important constraints were the low selling price of maize (20% and 18% of adopters and non-adopters, respectively) and lack of credit (12% of adopters and 18% of non-adopters).

Table 6. Most important maize varieties grown (1996 -1998), Embu District, Kenya.

	Farmers (%)					
Variety	**LR 1996**	**SR 1996**	**LR 1997**	**SR 1997**	**LR 1998**	**SR 1998**
H513	0	0	0	1.6	0	4.1
H511	34.1	38.9	17.5	17.9	13.0	14.6
H512	14.3	12.7	9.5	7.3	7.3	4.9
C5222	0	0	0	0	0	0.8
Pan 5195	0.8	1.6	0	0.8	0	0.8
CG 4141	0	0	0	0	0	1.6
PHB 3253	0.8	2.4	25.4	33.3	34.1	34.1
H614	3.2	1.6	2.4	1.6	2.4	0
H611	0	0	0	0	0	0
H626	0.8	0	0	0	0	0
H625	5.6	1.6	3.2	0.8	3.3	0
Katumani	0.8	1.6	0.8	0	0.8	1.6
Makueni	0	0.8	0	1.6	1.6	1.6
Recycled seed	40.5	41.3	43.7	39.0	43.1	44.7

Note: LR=long rains; SR=short rains.

Popular maize varieties and seed package size

Farmers were asked which varieties they favored (a yes or no answer, but each farmer could opt for more than one variety). Pioneer 3253 was the most popular maize variety (Table 7) followed by H511, Makueni, and H512. Pioneer 3253 was popular because of its high yield and early maturity despite its high price, poor storage, and root lodging (Table 8). Other valued traits were pest and drought tolerance, large grains, good threshing quality, taste, and ease of cooking. Both H511 and H512 were valued for their high yields and early maturity. H512 was also valued for its good taste.

Table 7. Maize varieties farmers value, Embu District, Kenya.

Variety	Adopters (%)	Non-adopters (%)	χ^2	All
PHB 3253	76.5	32.4	21.1***	60.9
H511	69.1	43.2	7.2***	59.9
H512	28.4	18.9	1.2 (NS)	25.0
H614	4.9	2.7	—[1]	4.1
H625	7.4	—	—[1]	4.8
Pan 5195	3.7	—	—[1]	2.4
CG4141	1.2	—	—[1]	0.8
Katumani	6.2	—	—[1]	4.0
Makueni	32.1	56.8	6.4**	40.9

Note: NS = not significant; ** = $p<0.05$; *** = $p<0.01$; —[1] = p not calculated.

Table 8. Attributes that farmers value in maize varieties, Embu District, Kenya.

	Phb 3253 (%)		H511 (%)		H512 (%)	
Attributes	Adopters	Non-adopters	Adopters	Non-adopters	Adopters	Non-adopters
High yield	93.2	90.0	52.7	73.3	81.0	100.0
Easy to cook	3.4	—	5.5	13.3	14.3	—
Early maturing	44.1	90.0	63.6	73.3	38.1	28.6
Pest tolerance	10.2	—	14.5	6.7	14.3	—
Stores longer	5.1	—	14.5	13.3	9.5	—
Good taste	6.8	20.0	18.2	—	19.0	42.9
Low price of seed	1.7	—	1.8	—	—	—
Large grains	10.2	—	5.5	—	9.5	14.3
Drought tolerance	8.5	—	3.6	—	—	—
Good anchoring	1.7	—	—	—	—	—
Threshing quality	—	—	1.8	—	—	—

Maize seed is available in 2-, 10-, and 25-kg bags. Most adopters (88%) preferred the 2-kg package, which is consistent with the small farm sizes reported in the study area (Table 9). Forty-nine percent preferred the 2-kg package because it was sufficient for the area allocated to maize, while 32% preferred the 10-kg package because it was affordable. Although the Kenya Seed Company (KSC) tried to accommodate smallholders by making seed available in 2-kg packages during the 1980s, this trend was reversed in the early 1990s in favor of 10-kg packages. The 10-kg packages accounted for more than 80% of all packages sold by KSC (Hassan et al. 1998). However, the present study revealed discrepancies between farmers' preferences and seed package sizes available at KSC—only 7% of adopters favored the 10-kg package, yet the most common seed package sold by KSC was 10 kg.

The price of a 2-kg improved maize variety package rose from 144 Kenya Shilling (Ksh)[1] in 1996, 189 Ksh in 1997 to 240 Ksh in 1998, a 67% increase in two years.

Table 9. Maize seed package preferred by adopters and non-adopters in Embu District, Kenya.

	Adopters (%)	Non-adopters (%)	All farmers
Package size			
Do not purchase	3.7	65.1	25.5
2 kg	87.8	30.2	67.4
10 kg	7.3	4.7	6.4
25 kg	1.2	—	0.8

Rate of Adoption of Improved Maize Varieties

Figure 2 shows the evolution of adoption of improved maize varieties in Embu District. The rates were derived by asking farmers the year they first planted improved maize seed, and then running cumulative frequencies to determine the proportion of farmers who adopted improved maize seed. About 75% adopted improved maize by 1997.

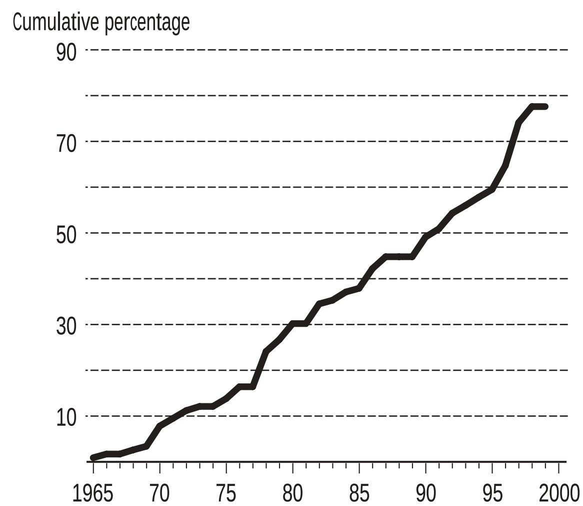

Figure 2. Evolution of adoption of improved maize varieties in Embu District, Kenya, 1965 to 1999.

The evolution of adoption of new technologies can be quantified by estimating the trend using time as a dependent variable in a regression on the adoption rate. Such a regression captures the historical trend of adoption over a given time and can be used to assess the effectiveness of agricultural institutions that have served the farming system over time. A linear regression is the most convenient, even though it has the disadvantage of having the dependent variable (adoption rate) fall partly outside the possible range (between 0 and 100%). Mathematically, the linear trend is given by the formula:

$$Y_t = a + bt$$

[1] US$ 1 = Ksh 60.263 (1998).

where:

Y_t = the cumulative percentage of adopters at time t

t = time (0=1965, 1=1966, …… 34=1999)

a = the intercept

b = the slope, indicating the change of adoption rate over time

An alternative measure is the use of a logistic curve, which has an S-shape and keeps the dependent variable between a minimum and maximum limit. The basic assumption is that adoption increases gradually and then accelerates to a maximum level (CIMMYT 1993). The functional form of the logistic curve is given by:

$$Y_t = K/(1+e^{-a-bt})$$

Where:

Y_t = the cumulative percentage of adopters at time t;

t = time (0=1965, 1=1966, …… 34=1999)

K = the upper boundary of adoption

a = a constant, related to the time when adoption begins

b = a coefficient related to the rate of adoption

Both functional forms were estimated (Table 10), but the linear model provides a better fit (R^2=0.98) than the logistic model (R^2=0.93). The coefficient b of the linear regression indicates that from 1965 to 1999, the adoption rate of improved maize varieties increased by 2.25% per year.

Table 10. Change in adoption rates of improved maize varieties over time (coefficients of linear and logistic regression).

	Linear		Logistic	
a	-5.058	***	0.346	***
	(1.080)		(0.048)	
b	2.253	***	0.864	***
	(0.055)		(0.006)	
R Square	0.98		0.93	
F	1701	***	432	***
Standard Error	3.26		0.42	
N	34		34	

Note: Standard errors of the coefficients are in brackets; *** = significant at the 1% level.

Soil Fertility Management

Fertilizer Use and Sources

Most surveyed farmers used basal fertilizer (98% of both types of farmers in the long rains, and 96% and 88% of adopters and non-adopters in the short rains, respectively) (Table 11). The use of top dress fertilizer in the long rains was more common among adopters of improved maize (44%) than non-adopters (17%) ($^2=9.4$; $p<0.05$). Compound fertilizer (23:23:23) was the main basal fertilizer used by adopters (52% and 55% in the long and short rains, respectively) and non-adopters (57.5% and 64% in the long and short rains, respectively). Calcium ammonium nitrate was the main top dress fertilizer used by both categories of farmers.

During the long rains, basal fertilizer was applied at an average rate of 2.9 and 2.2 bags/ha (50 kg bags/ha) by adopters and non-adopters, respectively. The average amount of basal fertilizer applied by both groups was 2.9 bags/ha. The difference of the means was significant ($p<0.05$). In the short rains, adopters applied 2.8 bags/ha, while non-adopters applied 2 bags/ha (Table 12). The difference was again significant ($p<0.05$). These rates were lower than the recommended rates.

Table 11. Fertilizer used by adopters and non-adopters, 1998, Embu District, Kenya.

Fertilizer	Adopters (%)	Non-adopters (%)	All
Basal fertilizer (LR)	97.5	97.6	97.5
Basal fertilizer (SR)	96.3	88.1	93.4
Top dress fertilizer (LR)	44.4	16.7	34.6
Top dress fertilizer (SR)	34.6	19.0	29.1
Fertilizer type (Top dress: LR)			
Calcium ammonium nitrate	100.0	87.5	95.6
Ammonium sulphur nitrate	—	12.5	4.4
Fertilizer type (Top dress: SR)			
Calcium ammonium nitrate	96.1	87.5	93.1
Ammonium sulphate nitrate	3.8	12.5	6.9
Fertilizer type (Basal: LR)			
Di-ammonium phosphate	27.7	17.5	24.1
20/20/0	19.3	25.0	21.3
23/23/23	51.8	57.5	53.8
Triple super phosphate	1.2	-	0.8
Fertilizer type (Basal: SR)			
Di-ammonium phosphate	22.9	17.9	21.1
20/20/0	19.3	17.9	18.8
23/23/23	55.4	64.1	58.5
Triple super phosphate	2.4	-	1.5

Note: LR = long rains; SR = short rains

Table 12. Nitrogen and phosphorus application, adopters and non-adopters, 1998, Embu District, Kenya.

Amount (kg / ha)	Adopters	Non-adopters	All farmers
Nitrogen (LR)	35.0	31.4	33.7
Nitrogen (SR)	35.2	32.8	34.3
Phosphorus (LR)**	46.8	34.5	42.4
Phosphorus (SR)	49.1	36.1	44.5
Basal fertilizer (50-kg bags / ha)			
LR	2.9	2.2	2.7
SR	2.8	2.0	2.5
Top dress (50 kg bags / ha):			
LR	2.3	2.7	2.4
SR	2.0	3.0	2.4

Note: ** = significant at $p<0.05$; LR = long rains; SR = short rains

The main sources of fertilizer were coffee cooperative societies (72% of 59 responses by adopters and 69% of 31 responses by non-adopters), local seed dealers (50% of adopters and 51% of non-adopters). Most farmers used fertilizer. Those who did not cited high price and unavailability.

Preferred Fertilizer Packages and Use of Organic Manure

The 50-kg fertilizer package was most preferred among adopters (76% of 62 responses) and non-adopters (72% of 31 responses). Fertilizer was used for maize and other crops, in particular, coffee. The 25-kg package was the second most preferred package among adopters (27%) and the 10- and 25-kg packages among non-adopters (16% and 19%, respectively). Most farmers (95% and 96% of adopters and non-adopters, respectively) reported that they had easy access to the packages they preferred. About 96% of adopters and 81% of non-adopters reported that they applied manure in their maize fields. This difference was significant at $p<0.01$. Cattle manure was the main organic fertilizer (98% of 77 responses for adopters and 97% of 36 responses for non-adopters).

Rate of Fertilizer Adoption

Figure 3 indicates that non-adopters of improved maize were a few years behind adopters in fertilizer use. In 1998, at least 90% of adopters and non-adopters used fertilizer.

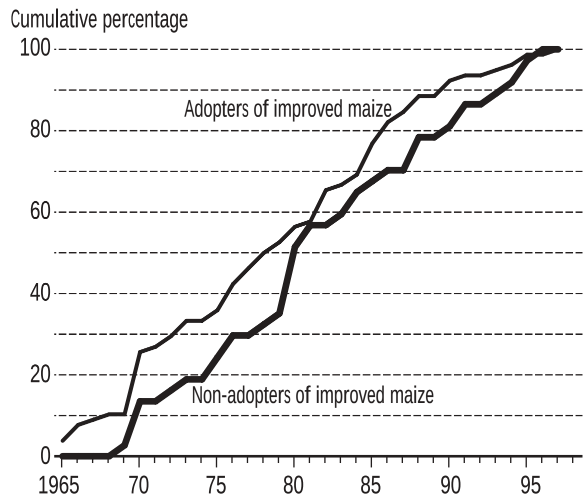

Figure 3. Evolution of fertilizer adoption for adopters and non-adopters of improved maize, Embu District,Kenya.

Access to Rural Support Services

Credit Use and Access

More adopters (78%) than non-adopters obtained credit from cooperative societies in the form of seed and fertilizer ($p<0.1$) (Table 13). About 66% of adopters used credit to purchase fertilizer for coffee and 49% for maize, while 56% of non-adopters used credit to buy fertilizer for coffee and 44% for maize. About 28% of both groups used credit for school fees. Credit was also used to purchase maize seed, animal feed, and to construct small maize mills. The average amount of credit was Ksh 6,802 for adopters and Ksh 3,613 for non-adopters. The coffee crop was used to obtain credit from the cooperative society. More than 28% of adopters cited availability of their own working capital and lack of interest as the reason for non-use of credit. Adopters (21.4 %) also thought it was uneconomical to use credit for maize production. For non-adopters, the main constraint was lack of collateral (71.4%).

Extension Services and Membership in an Organization

Adopters of improved maize (90%) had better access to extension services than non-adopters (76%) ($p<0.05$). The main source of extension services was the Ministry of Agriculture (83% of 64 responses by adopters and 74% of 28 responses by non-adopters), NGOs (12% of adopters and 21% of non-adopters), and other farmers (18% of adopters and 16% of non-adopters). There was no significant difference between the numbers of adopters and non-adopters receiving advice on improved maize production, that is, 75%. The main extension advice was on fertilizer use (52% of 82 responses for adopters and 50% of 44 responses for non-adopters). Other important extension services were on seed (44%) and spacing (33%) for adopters, and for non-adopters (27%) on spacing. Thirty-five percent of adopters and 55.6% of non-adopters were visited twice in the last two years. More than 90% of both groups were members of a cooperative or farmers' group. The main service provided by these groups was credit to purchase inputs (68% and 62% of adopters and non-adopters, respectively).

Table 13. Farmers' access to rural support services, Embu District, Kenya.

Rural support services	Adopters (%)	Non-adopters (%)	χ^2	All
Credit	78.0	64.4	2.7*	73.3
Extension service:	90.2	75.6	4.9**	85.1
No. of visits in past two years:				
<5	55.0	74.1		61.6
5 –10	20.0	7.4		15.6
>10	25.0	18.5		22.7
Extension services on maize	80.5	68.9	2.2 (NS)	76.5
Membership in an organization	95.1	91.1	0.8 (NS)	93.7

Note: NS = not significant, * = significant at $p<0.1$; ** = significant at $p<0.05$.

Logistic Model Estimates

Factors influencing the adoption of improved maize were analyzed using maximum likelihood estimation of a logistic regression model. These results are presented in Table 14. The model has a correct prediction rate of 75%, correctly predicting adopters at 89% and non-adopters at 44%. Factors that influenced adoption were agroecological zone, gender, use of manure, and hiring labor (all with significantly different coefficients from zero to 10%).

Interpretation of the coefficient with the logistic regression model is not as straightforward as the linear probability (LP) model where coefficients estimate the change in probability to adopt. However, dividing the logit coefficients by a factor of 4 gives an approximation of the linear probability coefficients (Maddala 1983:23). Thus, the coefficient on gender is 2.21 and can be interpreted as an LP coefficient of 0.55. The interpretation is that men, keeping all other factors constant, have a 55% higher probability than women of adopting an improved maize variety. Comparing the coefficient with that of the other factors, gender is clearly the most important.

The second most important factor is the use of manure, with a coefficient of 1.82. Using the same reasoning, this indicates that farmers who use manure have a 45% higher probability to be improved maize adopters than those who do not. Farmers from the UM2 zone have a 34% higher probability (1.37/4) than those from the UM3 zone, and those who hire labor have a 32% higher probability. The smallest significant factor was extension – farmers with access to extension had a 24% higher probability to be improved maize adopters. Other factors hypothesized to influence adoption did not have significant coefficients. They included age of household head, education, farm size, credit, extension, area under coffee, and farmer group membership.

Table 14. Logit analysis for adoption of improved maize variety in Embu District, Kenya.

Variable	Coefficient estimate (B)	Standard error	*P*-value
Gender (0=women, 1=men)	2.21	1.06	0.04**
Farm uses manure (1=yes, 0=no)	1.82	0.82	0.03**
Agroecological zone (UM2=1, UM3=0)	1.37	0.60	0.02**
Farm hires labor (1=yes, 0= no)	1.29	0.55	0.02**
Access to extension (1=yes, 0=no)	0.95	0.57	0.10*
Use of credit (1=yes, 0= no)	0.95	0.61	0.12
Education of household head (yr)	0.04	0.08	0.59
Age household head (yr)	0.05	0.02	0.56
Farm size (acres)†	-1.25	1.08	0.25
Area under coffee (acres)†	-0.02	0.10	0.85
Member of farmer group (1=yes, 0= no)	0.05	0.33	0.87
Intercept	- 5.59	2.15	0.01**
Model χ^2	30.59		0.00***
Overall cases correctly predicted (%)	72.97		
Correctly predicted adopters (%)	88.0		
Correctly predicted non-adopters (%)	41.67		
Sample size (no.)	111		

Note:* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level. † 1 acre = 0.405 ha.

Factors that influence fertilizer use were analyzed by estimating a linear model since the dependent variable is quantitative (kg/fertilizer/ha) and almost all farmers use some fertilizer. Two different models are estimated: the first model uses total fertilizer use, expressed in kg/ha (first two columns of Table 15): the second model uses total phosphorus in kg/ha. Only three factors, hiring labor, credit, and education of household head, had a significant effect on the quantity of fertilizer used. Hiring labor increased the amount of fertilizer used by 45 kg/ha, while using credit increased it by 53 kg/ha. Education of the household head had an unexpected negative impact – for each year of schooling, fertilizer use decreased by 7 kg.

Table 15. **Linear regression model for fertilizer use, Embu district, Kenya (dependent variable is total fertilizer use in kg/ha and phosphorus in kg/ha)**

	Total fertilizer (kg/ha)		*P* (kg/ha)	
Explanatory variable	Coefficient estimate (B)	Standard error	Coefficient estimate (B)	Standard error
Gender (0=Women, 1=Men)	10.5	39.9	4.7	12.3
Farm uses manure (1=yes, 0= no)	-44.5	34.7	1.6	10.9
AEZ (UM2=1, UM3=0)	32.4	21.5	0.9	6.7
Farm hires labour (1=yes, 0= no)	45.4	23.6**	6.4	7.8**
Access to extension (1=yes, 0= no)	-1.2	24.2	5.83	7.9
Access to credit (1=yes, 0= no)	52.8	23.1*	0.5	7.3
Formal education of household head (yr)	-7.3	3.4**	2.3	1.1**
Age household head (yr)	-1.7	0.97	0.56	0.3*
Farm size (acres)†	-1.3	3.92	0.65	1.2
Area under coffee (acres)†	12.2	14.2	0.4	4.4
Member of farmer group (1=yes, 0= no)	-35.4	43.4	10.8	13.4
Intercept	260.2	78.9**	9.0	24.0***
R	0.409		0.138	
Sample size (no.)	111		**111**	

Note: *= significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.
† 1 acre = 0.405 ha.

The variable 'total fertilizer used' indicates a mix of fertilizer with different composition of nutrients. To avoid this accumulation problem, the nutritional components of each type were summed. The second model uses the amount of phosphorus per hectare in each farm. Hiring of labor is again significant (it increases *P* use by 6.4 kg), but credit is not. Formal education is again significant, but the opposite of the first model: for each year the *P* use increases by 2.3 kg. Age is also significant and increases *P* use by 0.56 kg for each year.

Conclusion

This study was undertaken to identify socioeconomic and technical factors affecting the adoption of improved maize seed and fertilizer use and the role of credit in both. The survey was conducted in Upper Midland 2 and 3 (UM2 and UM3) (Jaetzold and Schmidt 1983) zones in the Nembure, Runyenjes, and Kieni Divisions of Embu, which represents the main maize growing zones in the area. These zones are dominated by the coffee/dairy land use systems.

The study covered both the long and short rainy seasons**.** One hundred and twenty-seven farmers were randomly selected and interviewed. Using a structured questionnaire, data was collected on farmer and farm attributes and institutional structure. Adopters of certified maize were defined as farmers who planted certified maize for two consecutive seasons in 1998 and non-adopters were defined as farmers who planted local seeds, recycled hybrid seeds or recycled seeds of open-pollinated varieties for more than three seasons. A comparative analysis between adopters and non-adopters of improved maize seed was done. Since productivity gains from maize seed depend on simultaneous use of other inputs and particularly fertilizer, the level of fertilizer used by adopters and non-adopters was also determined. Logit and linear models were used to analyze factors affecting adoption of improved maize seed and quantity of fertilizer, respectively.

The study found that most adopters of certified seed preferred Pioneer H3253. While there was a marked increase in the use of Pioneer H3253 between 1996 and 1998, the proportion of farmers using older hybrid varieties, H511 and H512, decreased in the same period. Adopters preferred Pioneer hybrid for its high yield and early maturity, despite its high price, poor storage, and root lodging abilities. Other valued traits mentioned were pest and drought tolerance, large grains, taste, good threshing quality, and ease of cooking. Most adopters preferred the smaller 2-kg seed package because it was affordable and sufficient for their plots of maize.

The high price of improved maize seed was the main constraint for adoption for most farmers. Other constraints were the low selling price of maize and lack of credit.

Nearly all farmers used basal fertilizer. More adopters used top dress fertilizers than non-adopters. Compound fertilizer 23:23:0 was the main basal fertilizer, and calcium ammonium nitrate was the main top dress fertilizer used by both categories of farmers in the long and short rains. Most maize farmers in the study area applied much less than the optimal level of fertilizer.

Improved maize seed adopters used more labor for farm operations than non-adopters. More adopters obtained formal credit from co-operative societies in the form of seed and fertilizer ($p<0.1$). About half of adopters and non-adopters used credit to purchase fertilizer for coffee or maize. The average amount of credit was Ksh 6,802 for adopters and Ksh 3,613 for non-adopters. To get credit from the cooperative society, farmers had to deliver the coffee crop. The main reason cited by adopters for not using credit was availability of capital and that it did not pay to use credit in maize production. For non-adopters, the main constraint to credit use was lack of collateral.

Generally, adopters had greater access to extension than non-adopters. The main source of extension was the Ministry of Agriculture. More adopters than non-adopters received advice on improved maize production. However, this difference was not significant. The main type of extension advice was on fertilizer use.

Agroecological zones, gender, manure use, hiring of labour, and extension were statistically significant in explaining adoption of improved maize variety. Other variables, such as age and education of household head, farm size, credit, years of formal education, area under coffee, and farmer group membership, which were expected to influence adoption and fertilizer use were not significant (at 10% or lower probability level). Likewise, agroecological zone, gender, manure use, hiring of labour, and extension were important variables in explaining the amount of basal fertilizers farmers applied.

In light of the many attributes considered in variety selection, the use of recycled seed by some farmers on grounds of high price and unnoticed differences in yield of improved and recycled seed, it is necessary to focus on farmer participatory breeding to incorporate farmers' assessment of maize varieties in the research process. There is also need to undertake studies on the economics of seed recycling to establish whether there is justification for farmers using recycled seed. The packaging of maize seed in small and more affordable packages such as the 2-kg bags should be encouraged to increase adoption of certified maize.

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ANNEX

Table A1. Food and cash crops grown in Embu District Kenya.

Crops	Farmers growing (%)	
	Adopters	*Non-adopters*
Maize	100.0	100.0
Beans	96.3	97.8
Coffee	93.9	95.6
Napier	95.1	88.9
Bananas	68.3	53.3
Irish potatoes	24.4	41.2
Sweet potatoes	9.8	6.7
Mangoes	4.9	2.2
Macadamia	6.1	2.2
Cabbages	6.1	2.2
Tomatoes	1.2	2.2
Kale	4.9	6.7
Arrow roots	1.2	2.2
Avocado	1.2	2.2
Cassava	12.2	8.9

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