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Dissemination and Adoption of Conventional and Nutritionally Enhanced Highland Maize Varieties in Trans-Nzoia County, Kenya

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Maize is a major crop in eastern Africa in terms of production, consumption, and income generation. Significant progress has been made in research and development of improved technologies for growing maize. One of the major objectives is to develop maize varieties containing important traits such as pest and disease resistance, early maturity, high yields, and good nutritional quality. Most new varieties are designed to be adapted to wider agro-ecological zones.

Though the highland zones of the region are high-potential areas for maize production, only a few of the improved varieties adapted to the region have been accepted by farmers. In addition, conventional maize is deficient in lysine and tryptophan. Adoption of quality protein maize (QPM) could alleviate the hunger and malnutrition faced by the farming community in the region.

The main study objective was to evaluate the dissemination and adoption of conventional and nutritionally enhanced highland maize varieties in Trans-Nzoia County. A survey was conducted among both subsistence and commercially oriented farmers. The results indicated that socioeconomic characteristics were associated with hybrid adoption. Overall, more than 90% of farmers grow hybrids, but the slow pace of adoption of new varieties is a cause for concern. There was a strong correlation between hybrid adoption and seed-to-grain price ratio for both subsistence farmers and commercially oriented farmers. There is evidence of a commercial orientation in both subsistence and large-scale farmers and hence the necessity to obtain seed maize at an affordable price. The willingness to grow QPM is a response to address protein inadequacy in the diet. The findings of this study should be very useful to policy makers when designing public awareness programs and promoting maize technology among farmers.

Key words: dissemination, adoption, maize varieties, Quality Protein Maize, Trans-Nzoia County

Introduction

Agriculture in Kenya continues to be a lifeline for the majority of the rural poor. The agricultural sector contributes up to 28% of the total gross domestic product (World Bank, 2011). About 79% of the total population of 40 million people reside in the rural areas and heavily rely on agriculture for most of their income and livelihood (IFAD, 2011). Despite its significance as a primary source of livelihood, the agricultural sector is afflicted by several challenges that are especially predominant in the high-potential highland tropics and moist transitional zones but also affect arid and semi-arid areas. The level of crop productivity is below potential and in recent years, the yield and value of some agricultural products have either remained constant or declined (Government of Kenya, 2010).

Maize (Zea *mays*) is the main staple food in Kenya (Wekesa *et al*., 2003). It is estimated to account for more than 20% of total agricultural production and 25% of agricultural employment (Muasya and Diallo, 2001). According to FAO statistics for 2005–2007, maize represents about 68% of daily per capita cereal consumption, 35% of total dietary energy consump-

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tion, and 32% of total protein consumption (FAO, 2010). Thus, Kenya's national food security is strongly linked to production of adequate quantities of maize to meet an increasing domestic demand (Odendo *et al*., 2001).

Kenya has 1.6 million ha of maize, and there is limited potential for further expansion since most of the arable land in Kenya is already under cultivation (Kibaara, 2005). Therefore, future increase in maize production will be achieved by improving yield per hectare rather than by expanding the production area. The average maize yield is about 1.8 t/ha but the yield potential is estimated to be over 6 t/ha (FAOSTAT, 2010). This yield potential could be exploited by focusing on improving maize yields, particularly in marginal areas. This could be achieved through the adoption of productivity-improving technologies such as increased use of hybrid maize and application of fertilizer by small-scale maize producers, who make up 70% of the country's maize production (Ministry of Agriculture, 2006).

Africa shares a unique relationship with maize. After its introduction by New World explorers, maize was quickly adopted as the cornerstone of local cuisine, especially in sub-Saharan countries. Although maize provides macro- and micronutrients required by humans, it lacks adequate amounts of the essential amino acids lysine and tryptophan. For those who obtain >50% of their daily energy from maize, pandemic protein malnutrition may exist. Severe protein and energy malnutrition increases susceptibility to life-threatening diseases such as tuberculosis and gastroenteritis. A nutritionally superior type of maize known as quality protein maize (QPM) represents nearly one-half century of research dedicated to malnutrition eradication. Compared with traditional maize types, QPM has twice the amount of lysine and tryptophan, as well as protein bioavailability that rivals that of milk casein. In Kenya, QPM is quickly gaining popularity among smallholder farmers (Nuss and Tanumlhardjo, 2011).

About 75% of the maize produced in Kenya comes from small-scale producers. Kenya has pursued the goal of food sufficiency in key commodities including maize; however, the attainment of self-sufficiency does not imply household food security. Several factors such as maize prices, distance to market centers, access to credit, access to information on hybrids and household income are more important for household food security. With the increase in human population, food production has declined at the same time that demand for food has increased.

Kenya has recorded great success in adoption of hybrid maize since the initiation of a comprehensive maize breeding program in the 1960s and 1970s. Improved maize hybrids have been rapidly adopted in the high-potential areas (highland tropics and moist transitional zones), where hybrids are grown by over 90% of the farmers and account for a large proportion of the maize area planted. In contrast, adoption of hybrids has been much slower in the low-potential areas (Lynam and Hassan, 1998).

Despite these improvements, policy researchers have recently lamented that early gains in maize productivity have not lived up to their potential (Karanja, 1996; Lynam and Hassan, 1998; De Groote *et al*., 2005). Rates of growth in maize production have not kept pace with demand (which is in large part driven by population growth), so the country's import bill has risen during recent years (Kirimi *et al*., 2011).

Maize production for the last few years has been below the national consumption level. Numerous explanations have been advanced for the current scenario. Some of the arguments that have been put forward are that breeders may have failed to surpass the quality of earlier releases (Karanja, 1996), that high population densities in rural areas may have created inefficient farm size and resulted in a decline in soil fertility (Lynam and Hassan, 1998; Byerlee and Heisey, 1997), liberalization of seed production has limited the availability of improved hybrid seed (De Groote *et al*., 2005). Although Kenyan farmers generally have a long experience with hybrid seed, adoption of maize hybrids per se is less important for maize productivity in Kenya today than is replacement of old hybrids with new ones.

Maize improvement efforts by various researchers and farmers date back to as early as the 1920s. The government of Kenya responded to the demands of large-scale maize farmers by initiating a systematic germplasm improvement program in 1955. This led to the development of late-maturing varieties suitable for highly productive areas. Later, early-maturing varieties were developed for use in marginal areas.

The first maize hybrid released in Kenya was H611 (Hybrid 611), in 1964 (Karanja, 1996). It was a cross between an open-pollinated variety, Kitale Synthetic II, and an improved Ecuadorian landrace, Ecuador 573.

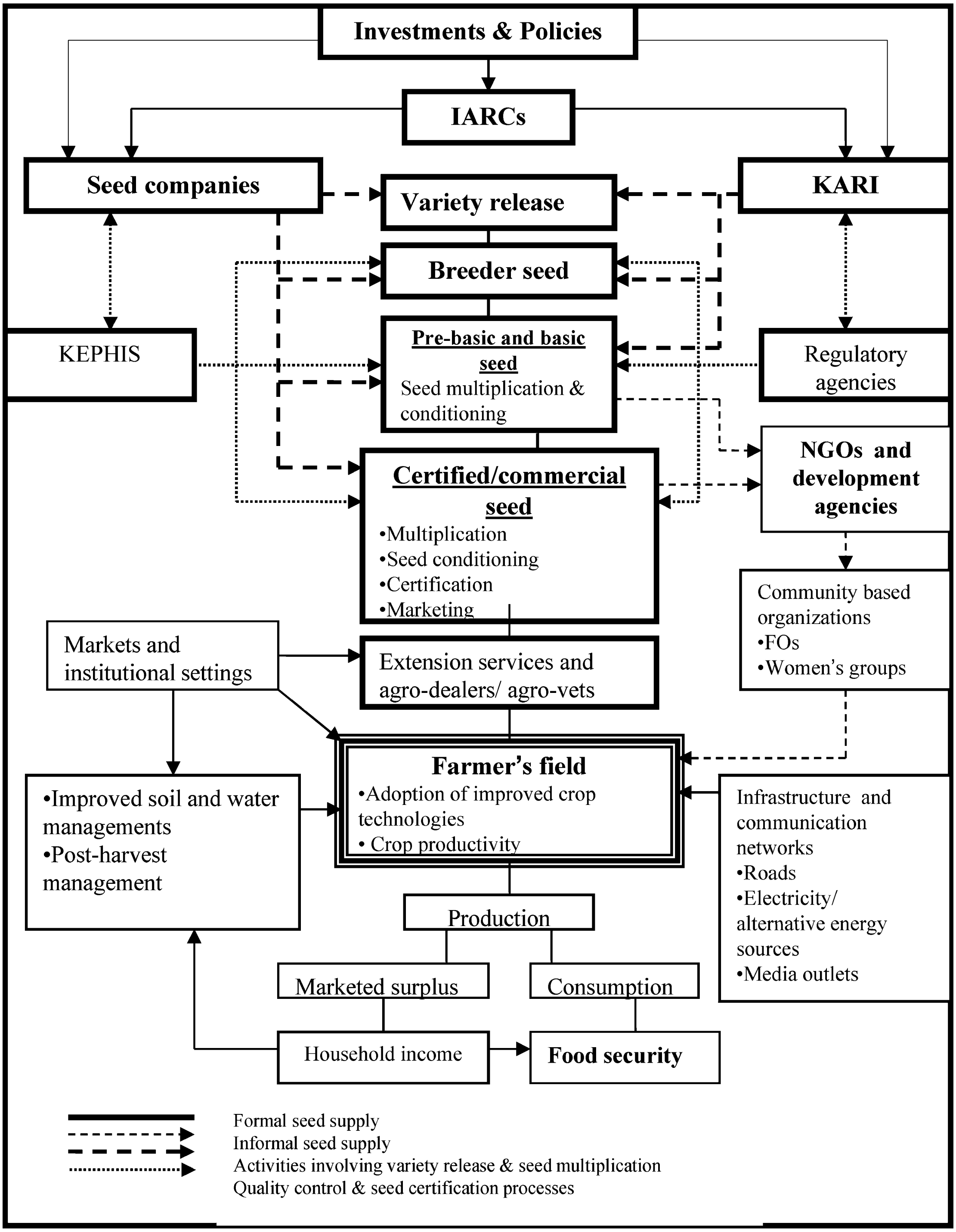

Fig. 1. Conceptual framework for crop technology systems in Kenya (Source: http://www.resakss.org Technologies for Enhancing Productivity of Cereals, Pulses, Roots and Tubers in the Arid and Semi-Arid Lands of Kenya).

H611 had a 40% yield advantage over Kitale Synthetic II, had lower seed costs than conventional hybrids, and had less yield loss when seed was saved and replanted (Smale and Jayne, 2003). This formed the basis of maize hybrid development in Kenya. Use of H611 spread among both large- and small-scale farmers in the high-potential areas of western Kenya at a high rate. Currently, there are many maize hybrid varieties being released every year for the different agro-climatic zones, though the adoption rate has not kept up with the pace of release.

Maize is grown in all of the agro-ecological zones in Kenya, by both large- and small-scale farmers. Hybrid varieties are released with respect to different agro-ecological zones. The white semi-dent grains have been bred and selected for various climatic conditions and altitudes (Kenya Seed Company, 2010). These are varieties suitable for medium- to high-altitude areas (1500–2100 m a.s.l.) with day temperatures of up to 28℃ during the growing season and with night temperatures dropping to as low as 8℃. H627, H626, H625, H629, H614, H6210, and H6213 are some of the varieties that have been released for the highlands. The precipitation requirements of these hybrids range from 800 to 1500 mm (Kenya Seed Company, 2010)

The first formal seed trade in Kenya began with the establishment of the Kenya Seed Company (KSC) in 1956. The main business of KSC is maize, which covers up to 90% of the formal marketed maize hybrids in Kenya. Until 1985, KSC relied on varieties developed by the National Agricultural Research Program of the Kenyan Agricultural Research Institute (KARI). However, since liberalization of seed production, many actors have come into play in the formal seed sector. KSC has also increased its scope and has intensified breeding programs for many other crops such as wheat and sorghum. Kenya has a well-developed seed certification and seed delivery mechanism compared to other countries in the region (Fig. 1). Today, the formal seed sector has attracted a number of specialized players, both public and private, who are involved either directly or indirectly in areas such as breeding, seed multiplication, quality control, processing, storage, marketing, and seed distribution (Wulf and Torp, 2006).

Maize varieties differ greatly in time to maturity, which is influenced by climatic conditions and other factors. The choice of variety is one of the most important decisions that a farmer has to make. Farmers choose varieties based on many criteria; among the most important of these are suitability for the agro-climatic environment and cropping system being used, disease resistance and tolerance, pest resistance, maturity period, kernel size, crop uniformity, drooping of the mature ear which prevents the rotting of the cob, and yield potential.

The main objective of this study was to explore why maize hybrids are not widely adopted by small-scale farmers in Trans-Nzoia County, Kenya. The study also sought to identify the factors that influence farmers' adoption of improved maize varieties. This was achieved through literature review and administration of a questionnaire to obtain first-hand information from farmers in the country.

Materials and Methods

Study area

Trans-Nzoia County is one of the 47 Counties located in the North Rift region of Kenya. It is bordered by the Republic of Uganda to the west, West Pokot County to the north, Marakwet County to the east, Uasin Gishu County to the southeast, and Bungoma County to the southwest (Fig. 2). The county lies between longitudes 0°52′ and 1°18′N and latitudes 34°18′ and 35°23′E. Trans-Nzoia County has three administrative sub-counties: Trans-Nzoia East, Trans-Nzoia West, and Kwanza. The County is further subdivided into eight administrative wards. The County covers an area of 2487 km^2, of which about 2000 km^2 is arable land.

The main topographical features in the county are Mt. Elgon (4313 m) in the west, Cherangany Hills (3371 m), and the Nzoia River, which flows into Lake Victoria. The county has a highland equatorial climate with rainfall distributed evenly throughout the year. The average annual rainfall ranges between 700 and 2100 mm per annum, and the temperature range is between 11 and 25℃. The rainfall pattern is bimodal, with long rains from April to June and short rains from August to October

Generally, the county is flat with an elevation of 1800 m a.s.l. The Kitale-Endebess Plain is the best for maize and sunflower farming and covers about 50% of the county. The northern part that borders West Pokot is quite dry. The county is cosmopolitan and is settled by people from most ethnic communities in the country, including Luhya, Kikuyu, Kisii, Kalenjin, and Pokot.

Trans-Nzoia County has a population of 818,757, among which 236,218 live in Kwanza, 387,366 in Trans-Nzoia West, and 195,173 in Trans-Nzoia East (Population and Household Census Report, 2009). Fifty-four percent of the population in the county lives in absolute poverty.

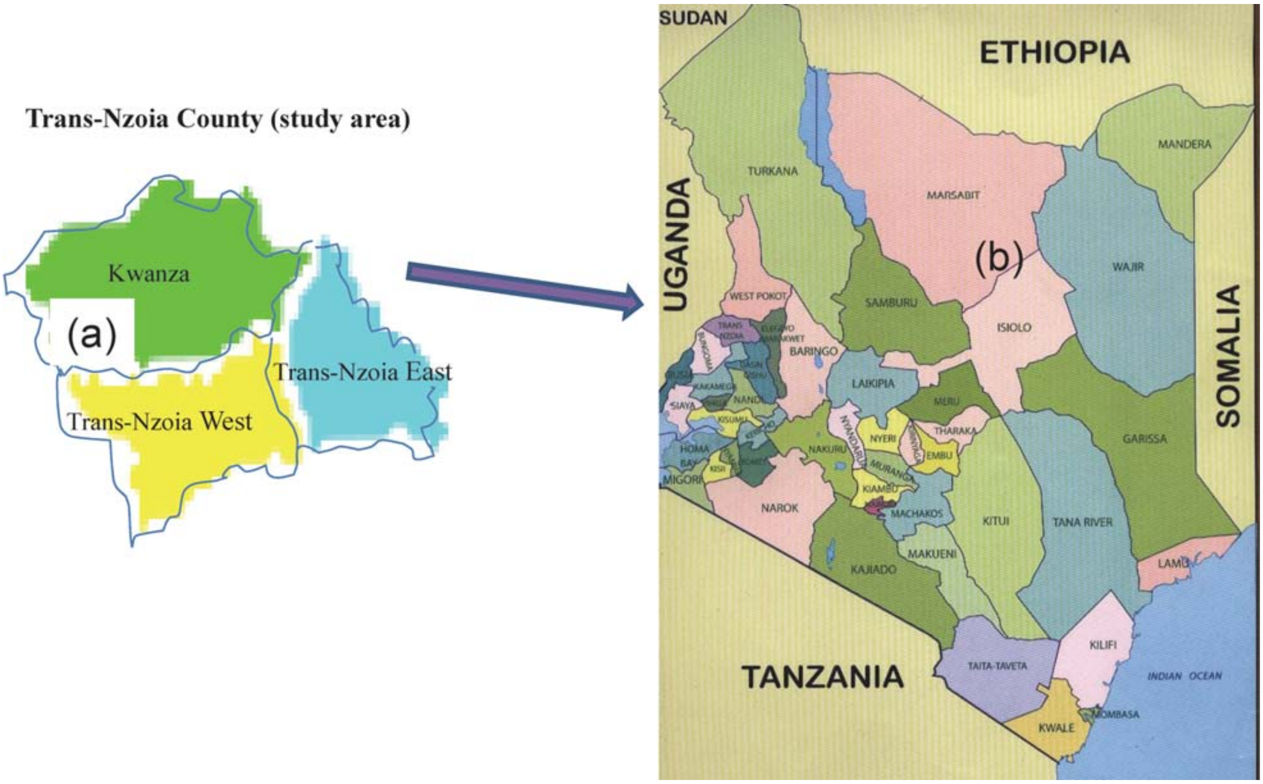

Fig. 2. (a) Location of Trans-Nzoia County. (b) County map of Kenya (Source: http://softkenya.com/map/kenya-county-map/

Agriculture is the main economic activity in the county. The main food crops are maize, beans, Irish potatoes, sweet potatoes, sorghum, cassava, and millet. Wheat, coffee, seed maize, sunflower, and horticultural crops are the main cash crops.

Data collection and analysis

A cross-sectional survey design was used for the study. Participants drawn from the eight wards of the county were interviewed using a semi-structured questionnaire (Appendix 1). Villages from the existing wards were randomly selected, a sampling frame made, and respondents randomly selected. The survey was carried out in August 2013 and covered 80 households. The number of valid questionnaires for analysis was 74, mainly from small-scale farmers but a few from large-scale farmers.

Qualitative and quantitative data on respondents' use of hybrid maize and QPM were collected. The dependent variables analyzed included the use of hybrid maize varieties and the quantities used. A model using the independent variables was developed and used to estimate adoption of hybrid maize and the scale of use of the improved seed.

A limited dependent variable model was specified to predict the probability that an individual, given his or her characteristics and socioeconomic attributes, would be willing to adopt and use improved seed. This model assumes that in making such a decision or commitment, an individual possesses a utility ranking (y*) that cannot be directly observed, and that the individual will be willing adopt new maize varieties if y* surpasses a threshold level. If it does, then we observe a highly likely response; otherwise, we observe a hardly likely response.

The model is stated as:

$$Y_i=\beta_0+\beta_1 GENDER+\beta_2+HHS_i+\beta_3 AGE_i +\beta_4 EDU_i+\beta_5 ANNINCO_i+\beta_6 S{:}G_i +\beta_7 KNHB_i+\beta_8 PLTHB_i+\beta_9 QTYHB_i +\beta_{10} ACCINF_i+\varepsilon_i$$

where $Y_i=1$ if y* > the threshold value and $Y_i=0$ if y* ≤ threshold value. The β values represent the model coefficients, measuring the marginal impact of each explanatory variable. ε_i is a random error term, and

Table 1. Descriptive statistics for use of hybrid seed by farmers

Variable	Description	Mean	Std. Dev.
Gender	1=Female; otherwise 0	0.345	0.46865
HHS	Household size	6.457	2.5278
AGE	Age in years	47.6	13.789
EDU	Education in years	10.9	0.2446
Loc	1=Urban; 2=Rural	1.057	0.1014
ANNINCO	Annual income in Kenya shillings	180450	14500
QTYHB	Quantity of hybrid planted last season in Kgs	50.8727	5.3363
Landsz	Land size cultivated	9.996	22.553
ACCREDIT	1=Access to credit; otherwise 0	0.8727	0.3364
KNHB	1=Basic knowledge on hybrids; otherwise 0	0.5818	0.4978
PLTHB	1=Plant hybrid seed; otherwise 0	0.9273	0.2621
ACCINF	1=Access information on hybrid; otherwise 0	0.8546	0.3413
S:G ratio	Scale comparing seed-to-grain price ratio	4.6153	0.6944

Table 2. Descriptive statistics for preference for nutritionally enhanced maize (QPM) by farmers

Variable	Description	Mean	Std. Dev.
Gender	1=Female; otherwise 0	0.2808	0.4548
HHS	Household size	7.2177	3.1817
AGE	Age in years	44.8	13.566
EDU	Education in years	12.169	2.4014
LOC	1=Urban; 2=Rural	0.4531	1.7155
ANNINCO	Annual income	165870	13937
QTYHB	Quantity of hybrid planted last season	40.883	2.356
KNHB	1=Basic knowledge on hybrids; otherwise 0	0.8080	0.339
ACCINF	1=Access to information on hybrids; otherwise 0	0.6507	0.1775
WILQPM	1=Willingness to grow/consume QPM; otherwise 0	0.7094	0.5590

the index i represents an individual respondent. The explanatory variables are defined as follows:

GENDER has a value of 1 if the respondent is female and 0 if the respondent is male.

EDU is the education level (in years) of the respondent.

HHS is the number of persons in the household.

AGE is a scale representing the respondent's age.

ANNINCO is a scale that measures monthly income.

ACCREDIT takes a value of 1 if the respondent has access to credit, otherwise 0.

KNHB takes a value of 1 if the respondent has basic knowledge on hybrid production, otherwise 0.

QTYHB is a scale representing the quantity of hybrid seed planted (in kilograms) by the respondent last season.

PLTHB takes a value of 1 if respondent uses hybrid seed, otherwise 0.

S:G represents the seed-to-grain price ratio

ACCINF takes a value of 1 if respondent has access to information, otherwise 0 (Tables 1 and 2).

The dependent variable was defined to have a value of 1 for those respondents answering "yes," "very willing," or "somewhat willing," and a value of 0 for "no" or "very reluctant." Once transformation was done, the probability that $Y_i=1$ could be estimated by a particular cumulative distribution function for the model. A probit model was used, and by assuming a cumulative distribution function for a standard normal variable $Y_{i,}$, estimation of the probit model yielded values for the model coefficients. Regression analysis (probit model) was conducted on the data using Gretl Software Version 1.1 (http://www.gnu.org/licences/fdl.htm).

Results and Discussion

Socioeconomic and demographic factors

The choice of varieties preferred by farmers was influenced by several factors. The majority of farmers (52%) indicated that they considered yield potential to be the most important factor when choosing a variety. Another 25% of farmers considered pest and disease resistance, 15% of farmers considered suitability for the agro-climatic environment, and 8% desired drooping of the mature ear as the most important factor. These factors are consistent with results described by Schroeder *et al*. (2013), who explored why hybrid maize varieties are not widely adopted by small-scale farmers in Kenya. Lack of awareness of existing or newly released hybrid varieties, lack of hybrid varieties adapted to particular areas, lack of confidence in the quality of some hybrid maize seeds, poor access to agricultural input suppliers, low profitability due to high seed cost, inadequate access to credit, the need for fertilizer application and low literacy level have been found to be important factors explaining the low adoption rates by smallholder maize producers.

Data description and summary statistics: Model estimation and empirical results

Higher age of the household head positively and significantly affected the likelihood that a household would grow hybrid maize. Farmers' knowledge on the basic production of hybrid varieties influenced the likelihood for the preference for QPM. The estimated model coefficients, the associated *z*-ratios, and the marginal effects of the explanatory variables are reported in Tables 3 and 4. The tables also report estimated values of log-likelihood functions, chi-square statistics of model significance, and success rate of prediction by the model. From the results of the marginal effects estimation for adoption of hybrids by farmers, it is evident that socioeconomic and individual attributes have an association with the likelihood of hybrid adoption.

The coefficient of gender was negatively correlated (−1.67971) with adoption of hybrids and was significant at the 5% level, indicating less adoption of hybrid maize by the female respondents. On the other hand, male participants had a more positive attitude toward hybrid maize. Previous studies have shown that males have generally more positive attitudes to science and technology than females (Hoban, 2004). Females, especially from developing countries, are generally less interested, less knowledgeable, and less supportive of science and technology than males (Anunda *et al*., 2010). This could probably be due to the fact that females have less access to information on new technologies and extension services.

Farmers' awareness of existing or newly released hybrid varieties strongly depended on their access to agricultural information. An important source of information is extension. Adequate access of farmers to extension providers increases the likelihood of adopting new technologies such as hybrid maize. Hassan *et al*. (1998) showed that there might be a possible correlation between access to extension services and farmers' awareness and adoption of new technology.

The seed-to-grain price ratio had a statistically significant correlation with the choice to grow hybrid maize. The higher the prices paid for seed relative to the price of grain in the village, the lower the chances that a farm household will grow a hybrid. Heisey *et al*. (1998) provide some useful interpretation of the magnitude of these ratios, based on break-even yield gain curves constructed by Byerlee *et al*. (1993), to illustrate the expected profitability of hybrid maize for smallholder farmers. At a low seed-to-grain price ratio of 5:1, the yield advantage of hybrid seed needs not be large for the hybrid to be attractive, even if farmers' overall yields are low. At a high seed-to-grain price ratio of 20:1, the yield advantage must be fairly large for a hybrid to be attractive. Byerlee *et al*. (1993) concluded that low seed-to-grain price ratios are needed to encourage farmers to adopt hybrids during the emergence and growth phases of the maize seed industry, until the market for the grain is well established.

When the market is not perfect, decisions on which seed to plant are the outcomes of choices of consumption of agricultural inputs and product combinations different seed maize types used to maximize utility, subject to market constraints. In this case, crop variety choice decisions are based on the theory of the household farm used by Meng (1997), Van Dusen (2000), and Edmeades (2003) who explained the adoption of banana varieties by farmers in relation to the

Table 3. Parameter estimates for farmers' use of hybrid seed: probit model

	Coefficient	Std. Error	z	p-value[a]	
Constant	−6.04415	3.28353	−1.6007	0.03808	**
Gender	−1.67971	1.91104	−1.9099	0.00819	**
HHS	0.00699	0.15571	0.03955	0.76781	
AGE	0.07693	0.07146	1.5097	0.04901	**
EDU	0.20918	0.41605	1.2013	0.29772	
ANNINCO	0.000642	0.00051	1.2519	0.37090	
KNHB	1.019830	1.24020	1.0052	0.11760	
S:G ratio	7.096150	8.20528	2.7807	0.03209	**
PLTHB	0.865839	1.43787	0.6895	0.65907	
QTYHB	−0.991501	1.41529	−0.6635	0.71073	
ACCINF	−3.03644	1.93650	−1.5535	0.09771	*

Mean dependent var	0.710000	S.D. dependent var	0.000000
McFadden R-squared	0.689504	Adjusted R-squared	0.354656
Log-likelihood	−7.996749	Akaike criterion	40.91178
Schwarz criterion	55.09809	Hannan–Quinn	39.33128

Number of cases correctly predicted=49 (66.2%)
f(beta'x) at mean of independent vars=0.000
Likelihood ratio test: chi-square df14=39.4620 [0.0000]
Test for normality of residual -Null hypothesis: error is normally distributed
Test statistic: chi-square df(2)=12.7305 with p-value=0.00199066

[a] Asterisks (*) and (**) indicate variables significant at ($p<0.10$) and ($p<0.05$), respectively.

industry transformation taking into consideration the produce price in various households.

The observed seed-to-grain price ratio depends on the physical market infrastructure, variety grown, and price incentive paid for grain of a certain quality.

Conclusions

The current study has clearly demonstrated that seed-to-grain price ratio has a significant, strong, and negative effect on farmer demand for hybrid seed.

Since maize is a key food crop and an important source of income and employment for the majority of rural farm households, Kenya's food security and the welfare of its farming population is strongly linked to increases in the national maize production. Given the limited availability of arable land, there is no doubt that increases in maize yields can only be achieved by the use of modern technologies, in particular by the use of improved maize varieties (such as maize hybrids) and fertilizer. Thus, the potential of maize hybrids in Kenya actually lies in enhancing productivity and sustaining/improving food security. Since the majority of maize farmers in high-potential areas already grow maize hybrids, the potential of maize hybrids to enhance yields can only be fully exploited by promoting replacement of old germplasm with newly released materials. Instead of expanding the percent of farmers growing maize hybrids, what matters most today for national maize productivity in Kenya is the dynamic replacement of older with newer materials, as long as these newer materials truly represent an improvement over previously released hybrids.

Recommendations

To encourage the use of maize hybrids among farmers in high-potential areas, the key factors influencing the adoption of hybrid seeds in small-scale maize production must be addressed. Maize sector policy interventions should focus on strengthening extension services, especially in areas where lack of awareness/knowledge is cited as a hindrance to adoption. Infrastructure like rural access roads and market

Table 4. Parameter estimates of preference for nutritionally enhanced maize (QPM): probit model

	Coefficient	Std. Error	z	p-value[a]	
Constant	−2.00963	2.3077	−1.8805	0.11380	
Gender	0.139877	0.188809	0.6170	0.59374	
HHS	0.095434	0.0899096	0.8433	0.39904	
AGE	0.0463265	0.0174408	0.6371	0.22421	
EDU	0.0337643	0.0558524	0.8001	0.49540	
ANNINCO	−5.09907e−06	2.01884e−05	−0.2054	0.99116	
LOC	0.31033	0.497299	0.4089	0.56373	
KNHB	1.67520	0.536822	2.9912	0.01697	**
WILQPM	0.720069	0.524550	2.0988	0.02829	**
ACCINF	1.618896	0.758089	1.7537	0.17082	
PLTHB	−0.820074	0.449722	−1.9211	0.05930	*
QTYHB	0.0486364	0.845885	0.0669	0.89005	

Mean dependent var	0.75968	S.D. dependent var	0.151075
McFadden R-squared	0.32802	Adjusted R-squared	−0.035596
Log-likelihood	−40.01250	Akaike criterion	88.2239
Schwarz criterion	120.4080	Hannan–Quinn	105.3506

Number of cases correctly predicted=48 (64.8%)

f(beta'x) at mean of independent vars=0.271

Likelihood ratio test: chi-square df(14)=24.5254 [0.0203]

Test for normality of residual -Null hypothesis: error is normally distributed

Test statistic: chi-square (2)=1.043721 with p-value=0.49409

[a] Asterisks (*) and (**) indicate variables significant at ($p<0.10$) and ($p<0.05$) respectively).

centers should be improved in order to reduce transaction costs and improve smallholders' access to agricultural inputs. The presence of a vibrant and competitive seed market that is fully liberalized and an effectively working regulatory body in place can improve adoption of hybrid seed. Though the price of improved maize varieties is still high for small-scale farmers, the entrance of many players into the market and increased level of competition will drive the prices down, thus making hybrid seeds more accessible to resource-poor farmers.

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Appendix 1

Sample questionnaire for collected household data

Section 1: Demographics

1. Name of household head
____
2. Location ____
3. Gender (i) Male (ii) Female
4. Age of household head
____
5. Size of household
____
6. Marital status
i) Single ii) Married iii) Widowed
7. Education: Number of years of formal education
____
8. Distance to the nearest market (km)
____
9. Location of residence
i) Urban ii) Rural
10. Which one among the following do you consider as your main means of livelihood according to a rank of 1−4 (where 4: Extremely important, 3: Very important, 2: Important and 1: Not important)

Crop production	☐ 1	☐ 2	☐ 3	☐ 4
Livestock production	☐ 1	☐ 2	☐ 3	☐ 4
Trading in agricultural products	☐ 1	☐ 2	☐ 3	☐ 4
Trading in livestock products	☐ 1	☐ 2	☐ 3	☐ 4

11. Annual income in Kshs.____
12. Total value of owned assets in Kshs.______________________________________
13. Do you think maize is key to food and nutritional security?
i) Yes ii) No
14. What is the size of the land you farm (including hired land)?
____
15. What is the size of the land you own?
i) Small scale: Less than 10 acres
ii) Medium: 10−39 acres
iii) Large scale: More than 40 acres

Section 2: Knowledge and experience on production of hybrid maize.

16. Do you plant any hybrid maize variety?
i) Yes ii) No
17. If yes, state the variety/varieties you planted last season
____
18. How many acres of each variety did you plant?
____
19. How many kilograms of hybrid seed did you plant last season?
____
20. How long have you grown the variety/varieties stated above?
____
21. What are the benefits of hybrid maize varieties? (You can include more than one option)
i) High yield
ii) Pest and disease resistance

iii) High price
iv) Enhanced nutrition

22. Which plant product qualities and composition would you prefer increased or optimized? (You can include more than one option)
i) Proteins (amino acids)
ii) Vitamins
iii) Carbohydrates
iv) Oil content

23. State the most important criterion you consider when choosing a seed maize variety
____

24. Do you access credit to finance hybrid maize production?
i) Yes ii) No

Section: 3 Awareness and knowledge of quality protein maize

25. Are you aware of any maize varieties with enhanced protein quality?
i) Yes ii) No

26. Is protein quality a limiting factor in the conventional maize you currently consume?
i) Yes ii) No

27. In your opinion, which statement best describes the percentage of farmers growing protein-enhanced maize?
i) None
ii) Less than 25%
iii) 26–50%
iv) More than 50%
v) Everybody

28. Are you growing any protein-enhanced maize variety?
i) Yes ii) No

29. If yes, what are the benefits of the protein-enhanced maize variety?
____

30. What would discourage you from growing a protein-enhanced maize variety? (You can include more than one option)
i) Cost of seeds
ii) Availability of seed
iii) Knowledge about utilization
iv) Market for grain

31. On a scale from 1–5 (where 1 is high and 5 low), rate how willing you are to consume/grow protein-enhanced maize.
1) Very willing
2) Somewhat willing
3) Neither willing/likely nor reluctant
4) Somewhat reluctant
5) Very reluctant

Section 4: Information dissemination and sharing

32. Do you have access to adequate information on improved maize varieties?
i) Yes ii) No

33. Where do you get information on improved maize varieties? (You can include more than one option)
i) Radio
ii) Television
iii) Newspapers
iv) Extension officers