PERCEPTION OF SEED FRAUD AND FARMER BEHAVIOR: VALUE OF MAIZE SEED CERTIFICATION IN KENYA

by

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ABSTRACT

Seed fraud is an emerging problem in Kenya. Seed companies have recently started marketing their improved seed varieties with novel features to ensure farmers of its authenticity. However, no study has investigated how farmers perceive the new certification features on seed packets nor estimated how much farmers discount seed packets that have been tampered with. Using an economic field experiment, this study analyzes 1) the value farmers attach to new seed certification features and the discount they apply to tampered packets, 2) the effect of training about best seed purchasing practices on farmers' willingness to pay (WTP) for seed packets, and 3) the effect of perceptions of seed fraud on farmer's WTP for improved varieties. The Becker-DeGroot-Marschak (BDM) mechanism was used to elicit participants' WTP for six different maize packets, including a seed packet directly from the seed company, four packets purchased from multiple sources (three had been tampered with), and a packet of local seed. Participants were willing to pay a premium for a seed packet purchased directly from the seed company. Farmer training on best seed purchasing practices led to a significant reduction in WTP for tampered packets. Perceptions about the prevalence of seed fraud had no effect in WTP. Substantial effort will be needed to educate farmers on how to identify high-quality genuine agricultural inputs, like improved seed varieties. Quality assurance and frequent training

on best seed purchasing practices may be particularly valuable when fraudulent seeds exist in the market. Additionally, more information is needed on seed packets to help farmers make informed purchasing decisions – e.g. functions of certification features, the meaning and significance of the printed sampling date, and the introduction of warning labels.

Chapter 1

INTRODUCTION

1.1 Background Information and Problem Statement

Worldwide trade in counterfeit goods is valued at $461 billion and constitutes 2.5% of the worldwide exports (Walters 2017). “We interpret products whose concentration of active ingredients is well below what is advertised on the label as being a misrepresented to consumers, and therefore functionally counterfeit” (Ashour et al. 2017, p. 3). Africa is significantly affected by counterfeiting because weak governance, corruption, and insecure borders are common, creating a conducive environment for fabrication, which is exacerbated by the large population and high poverty levels (Walters 2017). This occurs often in every sector without considering the weight of the impact. About a third to three-fifths of the pharmaceuticals in Africa are counterfeits resulting in a million deaths. In Kenya, only 20% of drugs for malaria, which is one of the epidemic diseases, are genuine (Walters 2017). Counterfeiting occurs in seeds, fertilizer, and other agro-inputs (e.g. pesticides) and can be in the form of diluted inputs, bulking out of fertilizer, and dying of seed to imitate hybrid seed. Farmers are not sensitive to a slightly lower quality product as they still purchase it and discount it less which discourages sellers from promoting high-quality products (Bold et al. 2017). Facing high poverty levels in developing countries, farmers view cheaper products as a better option as they could buy more inputs for less with very little concern about the quality.

Counterfeit seeds are packaged in packets resembling genuine seeds making it difficult for consumers to distinguish them from genuinely certified seeds or other causes of low quality such as adulteration, poor storage, improper handling of products or errors in production (Ashour et al. 2017; Bold et al. 2017). Seed counterfeit has caused a loss of 350 million dollars in the seed agricultural sector in Africa (Deloitte 2014). This impact stems mainly from the difficulty to trace seeds along the distribution chain, reluctance of the seed company to intervene, inability of farmers to identify genuine products, and weak enforcement of regulations with 90% of all seeds supplied in sub-Saharan Africa coming from small and informal traders (Deloitte 2014; Shao and Edward 2014; Karingu and Ngugi 2013; Walters 2017). In Africa, fake agro-inputs make up a fifth of all agro-inputs in the market, while in Europe it is about five times less (Shao and Edward 2014). A study in Tanzania found out that 73.5% of respondents identified fake agro-input as a severe problem with almost half of them stating crop seed as the most common instance of counterfeiting (Shao and Edward 2014). Ninety percent of respondents reported a willingness to adopt technology-based solutions, like the Agro-Inputs Product Verification System (APVS) which involves verifying input authenticity by using a mobile phone to send a product code found on a scratch-off packaging label (Shao and Edward 2014). In their study, more than half of the farmers did not look for or check for features on the agricultural product package to verify its authenticity of input. Approximately 20% checked for the expiration date, and about 17% checked the packaging style and visible labels of the manufacturer (Shao and Edward 2014).

A study in Uganda showed that 60% of counterfeiting of agricultural inputs was caused by agro-dealers and informal salesmen removing genuine labels and placing them on substandard products (Deloitte 2014). The rest was done by manufacturers and distributors through mislabeling products – e.g., replicating labels and using them on inferior products (Deloitte 2014). A test of products in the local market in Uganda showed that 30% of the nutrients are missing in fertilizer (Bold et al. 2017). Hybrid maize seeds comprise less than half of genuine seeds, therefore, average returns for smallholder farmers would be over 50% if genuine technologies and products were used (Bold et al. 2017).

Counterfeit products negatively impact agricultural productivity and economic returns, thus limiting growth in affected regions (a loss of $500 million revenue in East Africa), destroying seed company reputations, causing consumer confusion, food shortages, loss of income, environment instability, and risks to public health and safety (Walters 2017; Karingu and Ngugi 2013). In Sub-Saharan Africa, on average, farmers lose $250 per hectare because of substandard fertilizer and hybrid seed with traditional farming techniques earning on average $320 per season per hectare (Bold et al. 2017). Deloitte (2014) proposed various measures that can be implemented to protect the consumers from this problem, including coin scratch labels (a pin code which when sent via call or text can authenticate the source), certified channels, smallholder education, track and trace technologies by manufacturers or investment in technologies that are difficult to imitate and quality assurance through independent testing in each stage of the supply chain. Instilling trust and educating consumers about how to identify genuine products from

counterfeits has a positive influence compared to sharing information on counterfeit products, which can have a negative effect on sales (Karingu and Ngugi 2013).

Increased concern about the prevalence of fake seed is an emerging problem in Kenya that limits smallholder farmers' willingness to invest money in maize seeds (Smale and Olwande 2014; Langyintuo et al. 2010; Odendo et al. 2002). In March 2018, 13500 kilograms of uncertified seeds including maize seeds worth KES 2.5 million were seized in Nakuru (Standard Digital 2018). Evidence on the true prevalence of fake seed in Kenya is mixed. A study by Kenya Agricultural Research Institute (KARI) reported that 75% of all farmers in Kenya had planted fake seeds at some point, in addition, approximately 40% of the seed packets tested in the study contained fake seeds. A study by Mburu et al. (2010) found that almost a third of their sample had encountered fake seeds. Mabaya and Mburu (2016) reported an 86% reduction in the number of officially reported cases of fake seeds over a 3-year period (2013-2016), and they attribute this to a lack of strict enforcement of the court system and law enforcement officers. Concern about seed fraud remains a major threat to seed companies. About 95.6% of hybrid maize seed grown are sourced from retailers, and 83% comes from Kenya Seed Company (Smale and Olwande 2014).

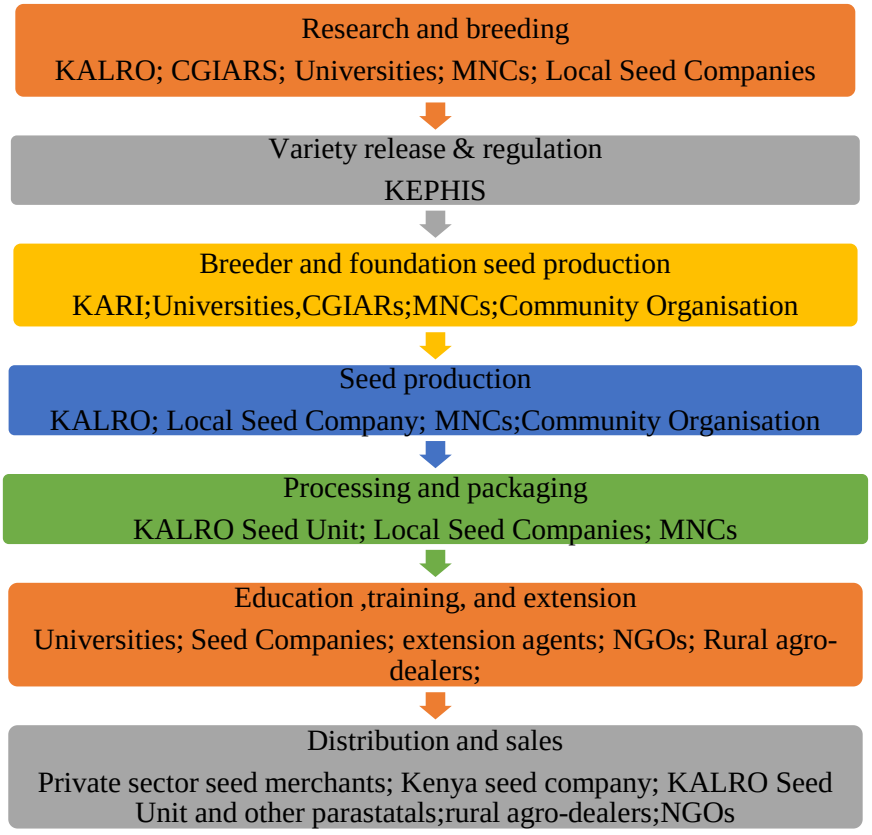
Farmers in Kenya are financially constrained; therefore, the presence of fake seeds in the market with a possibility of 40% chance of germination has caused severe losses (Standard Digital 2017). Delayed planting has worsened the situation as farmers miss out on the planting grace period (Standard Digital 2017). Farmers are willing to walk long distances to obtain genuine seeds from trusted traders (Mburu et al. 2010). Government regulatory agencies have failed to supervise seed certification and fight sale of counterfeit

or expired seed and with no strict enforcement of regulations and no harsh penalties in the law exist further worsening the situation (Smale and Olwande 2014; Standard Digital 2017). The fine fixed by the Kenyan law for issues relating to regulations and seed fraud is a maximum of $200 (KES 20000) or an imprisonment of six months or both. Fraudulent traders view these penalties as low potential costs compared to the potential gains from selling fraudulent seed.

Seed companies have lost confidence in the government seed regulatory board and its limited inspection, resulting in shops that are stocked with expired, fake or illegally-packaged seed (Mabaya and Mburu 2016). Strict policies along the certified seed value chain will instil trust regardless of the source of the seed (Mburu et al. 2010). The number of seed producing companies has increased, and with competition and aggressive marketing, it has created confusion in the market with little money being invested to educate farmers about these products increasing their susceptibility (Kamau and Baumgartner 2008). Farmers are more likely to purchase fake seeds if they do not verify the packaging including the quality of dye and stitching as most common types of counterfeiting is in form of labels, manufacturing and repackaging (Kamau and Baumgartner 2013; Karingu and Ngugi 2013).

Various organizations in Kenya and the government have introduced novel features to protect farmers from the purchase of fake seeds and enable the trace of seeds. Kenya Plant Health Inspectorate Service (KEPHIS), the only regulatory board in Kenya (Figure 1.1) in partnership with the Seed Trade Association of Kenya (STAK) has intensified protection of farmers by introducing scratch labels on packets of seed weighing up to 10

kg. The labels are embossed with the KEPHIS logo on gold foil and a lot number, which has enabled the identification of seeds based on the label alone (Mabaya and Mburu 2016). The scratch label on the seed packet has 12 digits which can be sent via short message service (SMS) for free, verifying its authenticity before leaving the point of sale (Shao and Edward 2014; Business Daily 2017). Farmers are advised to purchase seeds early in the season from established outlets with a KEPHIS license and not from open containers. In addition, the seed should be stored in a cool dry place (Kamau and Baumgartner 2013). Provision of information about a product's ingredients, the quality tests that it has undergone, and the certification of the testing agency reduces uncertainty in products (De Groote et al. 2016).



Key Acronyms: **KALRO** - Kenya Agriculture and Livestock Research Organization; **KEPHIS** - Kenya Plant Health Inspectorate Service; **MNC** - Multinational Corporation; **NGO** - Non-Governmental Organization; **CBO** - Community Based Organization; **FBO** –Farmer Based Organization; **KFA** –Kenya Farmers Association; **Gok** –Government of Kenya.

Figure 1.1: Formal Players in the Seed System in Kenya
Source: Mabaya and Mburu (2016)

When consumers cannot identify fake products in the market, it creates the lemons problem where they choose not to purchase the product because they do not have information about the true quality of the product and are not willing to pay a premium for the product (Ashour et al. 2017; Akerlof 1978). The lemon problem results from the inability of the buyer to know the real value of the product (Akerlof 1978). The lemon problem has been applied in various markets e.g. automobile, good, and money to understand the behavior of individuals under risk. Buyers invest in products or activities in which they know of its performance or the characteristics of the seller (Akerlof 1978). Both products are identical and sell at the same price with only the seller knowing the true quality (Akerlof 1978; Li 1995): through time and experience a buyer can judge whether it is of good quality or a lemon (low quality) with a certain probability (Akerlof 1978). The higher the selling price for lemons, the higher the prevalence of lemons (Wadleigh, Drew and Moore 2015). With complete or perfect information on quality only genuine products are sold but with severe private information, lemons exist (Li 1995). Buyers only accept products with unidentified qualities with higher discount rates (Li 1995). In a study in Singapore, lemons were found to have a negative effect on internet purchases and they were attracted to high-quality sellers because it was safe and assured of quality (Liaoa and Cheung 2001; Akerlof 1978).

Seed companies have recently started marketing their improved seed varieties with novel features to eliminate the lemons problem; however, awareness of these features is low among smallholders. No study has investigated how farmers perceive the new certification features on seed packets e.g. certification labels nor estimated how much farmers discount seed packets that have been tampered with. Certification features are designed to protect farmers from fraudulent seeds. This research analyzes the value farmers attach to certification labels and the effectiveness of training farmers on best seed purchasing practices in the identification of fake seeds. I also estimate how much farmers discount seeds that are sold in packets that have been tampered with compared to their WTP for intact, certified seed packets. I further looked at the effects of perception on seed fraud in WTP of maize seed packets. This enabled me to understand farmers' seed decision-making process in the presence of fake seeds. Training farmers on best seed purchasing practices were effective in identifying tampered packets. I identified policies that can be incorporated with the certification features to ensure farmers always purchase high-quality genuine seed. I also highlighted areas on a packet of seed that need improvement and what new information can be introduced on a packet of seed for quality assurance.

1.2 Research Questions

i) Do farmers place value on specific attributes of maize seed packets that help to ensure the seed's authenticity and quality, including a certification label with the KEPHIS logo, an intact packet seal, and a valid seed production or expiration date?

ii) Does providing information about best seed purchasing practices have an effect on farmers' willingness to pay for maize seed in different types of packaging?

iii) How do the answers to (i) and (ii) differ based on farmers' perceptions of seed fraud?

Chapter 2

LITERATURE REVIEW

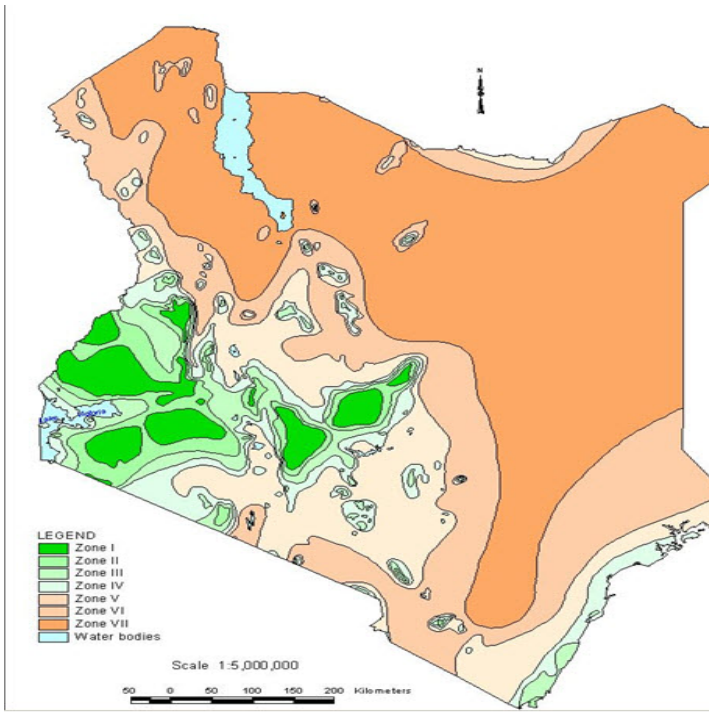
2.1 Maize Farming in Kenya

The rapidly growing human population in Sub-Saharan Africa has exerted pressure on the food production system. Kenyan agriculture is primarily a rain-fed system; thus successful production depends on climatic conditions. Sub-Saharan Africa will be more affected by food insecurity with relative crop yield (actual projected crop yield/ economically attainable yield under zero water stress) declining from 0.86 in 1995 to 0.75 in 2025 (Rosegrant, Cai and Cline 2007). A high proportion of arable land is already cultivated and with slow growth due to irrigation from surface water, cereal imports are projected to more than triple by 2025 (Rosegrant et al. 2007). Yields are below the global average and wheat yields are predicted to decline by nearly 72% relative to current yields alongside a 45% yield decline in maize, rice and soya beans and less than 20% yield decline for sorghum and millet (Adhikari, Nejadhashemi and Woznicki 2015).

Maize productivity in Kenya has been increasing for the past 10 years due to improved germplasm and fertilizer, however, it is still lower than the country's potential (Mburu et al. 2010). Productivity per hectare (in tonnes) is 2.7 lower than other developed countries stemming from the difference in farming technologies and climatic conditions (Mburu et al. 2010). Compared to other sub-Saharan countries, the rate of hybrid adoption

is high among maize farmers in Kenya. Improved seed varieties have the potential to increase yields for small-scale farmers, especially in areas where climate change is amplifying environmental challenges such as weather variability

Agriculture in Kenya is dominated by small-scale farmers, who constitute 75% of total agricultural production and 70% of marketed agricultural produce with a land size of about 0.2 to 3 hectares (Ogada et al. 2014; Suri 2011; Mabaya and Mburu 2016). Maize occupies the largest share of farmland compared to other crops. There are approximately 3.7 million acres of cropped land, and between 2.3 and 2.7 million metric tonnes of maize are produced in the main season with an average of 0.8 metric tonnes per acre (Suri 2011; Republic of Kenya 1994). Maize is the staple food for over 90% of the population and constitutes 42% of dietary energy intake (Odendo et al. 2002; Suri 2011; De Groote et al. 2005). About 70% of maize is grown by small-scale farmers for subsistence and this constitutes about 75% of total maize area (Odendo et al. 2002; Suri 2011; De Groote et al. 2005). Maize grows well in climatic zones II, III and IV and it has expanded to zone V (Figure 2.1) that is affected by frequent droughts and poor soil, due to population expansion in marginal areas (Mati 2000).



Agro climatic Zones	Moisture Index(%)	Annual Rainfall (mm)
I	>80	1100-2700
II	65-80	1000-1600
III	50-65	800-1400
IV	40-50	600-1100
V	25-40	450-900
VI	15-25	300-550
VII	<15	150-350

Figure 2.1: A Map[a] of Agro-Ecological Zones in Kenya with its Climatic Conditions[b]
Source: (http://www.infonet.biovision.org) [a] and Orodho (2006) [b]

In 2080, The World Bank predicts that Africa will have 50% of malnourished people worldwide and the most food insecure continent resulting from climate change (CIMMYT 2017). Intercropping and the use of improved seeds that are drought or disease resistance have become common in Africa and it has enabled farmers to have a fruitful harvest irrespective of the climate change (CIMMYT 2017). Climate change in semi-arid zones III-IV in Kenya by the year 2030 are projected to results in a temperature increase of 2.29℃ and 2.89℃, and rainfall will be unchanged with a shift in distribution; the short rain season (October-January) having an increase in rainfall and the long rain season (April-July) experiencing a decrease in rainfall (Mati 2000). In 2012, long season rains showed a reduction in the number of rainy days compared to short-season rains (Republic

of Kenya 2013). At high temperatures, temperature stress and moisture availability affect maize yields as the available soil moisture is unable to meet the increased water demand in rain-fed agriculture, thus decreasing maize yields. It is anticipated that Eastern Africa will lose 40% of its current yield by the end of 21st Century (Adhikari et al. 2015) having more impact to agricultural households whose source of livelihood depend on it (Macours 2013).

Farmers in Kenya grow improved maize varieties to adapt to climate change. Improved agricultural technologies (through a combination of natural resource management technologies, better seeds, increased level of other inputs and efficient dissemination of information in social networks) will reduce poverty and create a sustainable development (Wainaina, Tongruksawattana and Qaim 2016; Tjernström 2015). The number of the farmers who purchase maize seeds is 1.5 times more than those who plant their own seed, with 10% of the seed grown constituting of gifts, direct seed distribution, seed loan, vouchers, exchange seeds, and food aid (McGuire and Sperling 2016). Central and Rift Valley provinces have a high rate of use of hybrid maize varieties, followed by Western province then Eastern province and the lowest percentages being in Nyanza and Coastal province; also there is no national subsidy scheme for hybrid maize varieties (Smale and Olwande 2014). When crossing varieties scientists take into account and monitor characteristics that consumers value such as taste, cooking qualities, color, and preference as it increases acceptability of the new products (Kimenju, Morawetz and De Groote 2005). An average of over 14 new maize varieties have been released each year since 2000 and a total of over 200 varieties in 2014 (Tjernström 2015; Mabaya and Mburu 2016).

2.2 Seed Industry

"Seed is a vehicle linked to promoting productivity, nutrition and resilience: one entry point can potentially move forward multiple goals." (McGuire and Sperling 2016, p. 179). The formal seed sector (Figure 2.2) in developing countries, where quality, health and varietal identity standards are maintained, makes up 10% of the total seed sector while about half of the sourced seeds from local markets in the informal seed sector are guided by indigenous knowledge, standards and social structures (Mabaya and Mburu 2016; McGuire and Sperling 2016; Feed the Future 2017). Seed technologies can either be classified as a public good whereby seed can easily be stored and recycled or private good in which farmers cannot recycle because germination decreases for each reuse thus very difficult to store encouraging agribusiness investment in such goods (Feed the Future 2017).

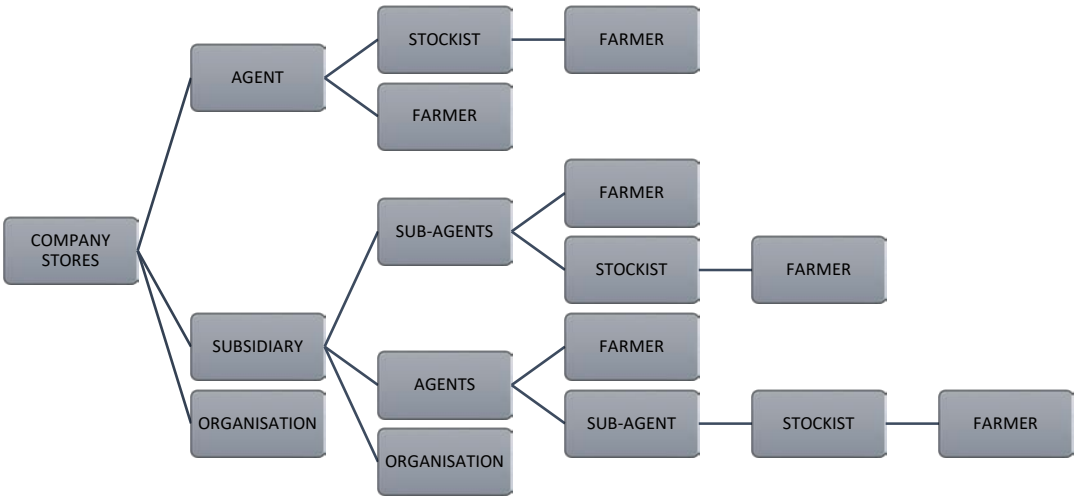


Figure 2.2: Formal Maize Seed Distribution Channel
Source: Kenya Seed Company Ltd

Chapter 326 (SEEDS AND PLANT VARIETIES ACT) of Kenya laws regulates all dealings of seeds including production, processing, testing, certification, and marketing of seeds. This act instills transparency and efficiency in the seed industry. It ensures information on the nature, condition, and quality of seed is available, all seeds growers and merchants are registered and control exports of seeds (GoK 2012). It also provides guidelines on the sale of seeds and prevents the sale of uncertified seed (GoK 2012). Some of the seed regulation offenses are dealings with uncertified seeds and the use of any prescribed name with the seed not grown/selected in the prescribed condition (GoK 2012). The laws state that any persons that transact with seed should have records of all the seeds transacted, statutory statements (concerning the implementation of seed regulation) and invoices on the sale of seeds, process or treatments on seeds, and the results of the test of the seeds.

There are over 130 seed companies in Kenya (KEPHIS 2017) and over 4,454 agro-dealers (Mabaya and Mburu 2016). KEPHIS a government parastatal, one of its jurisdiction is to carry out seed certification and regulate the importation and exportation of seeds based on national and international standards (KEPHIS 2017). Independence of the seed certification process ensures high-quality genuine seed. KEPHIS appoints authorized seed inspector, sampler or analyst and conducts training (on inspection, sampling, and testing) and monitoring as shown in Figure 2.3 (KEPHIS 2017). Certification labels are issued by KEPHIS when the seeds have met the minimum standards (KEPHIS 2017). This is done at the last stage (5^{th} stage) that regulates the acquisition of labels, sealing, and labeling of seeds for existing and new varieties. The other four stages involve seed field inspection, processing, sampling and testing of seeds. Re-inspection, re-sampling and retesting is only done by KEPHIS (KEPHIS 2017).

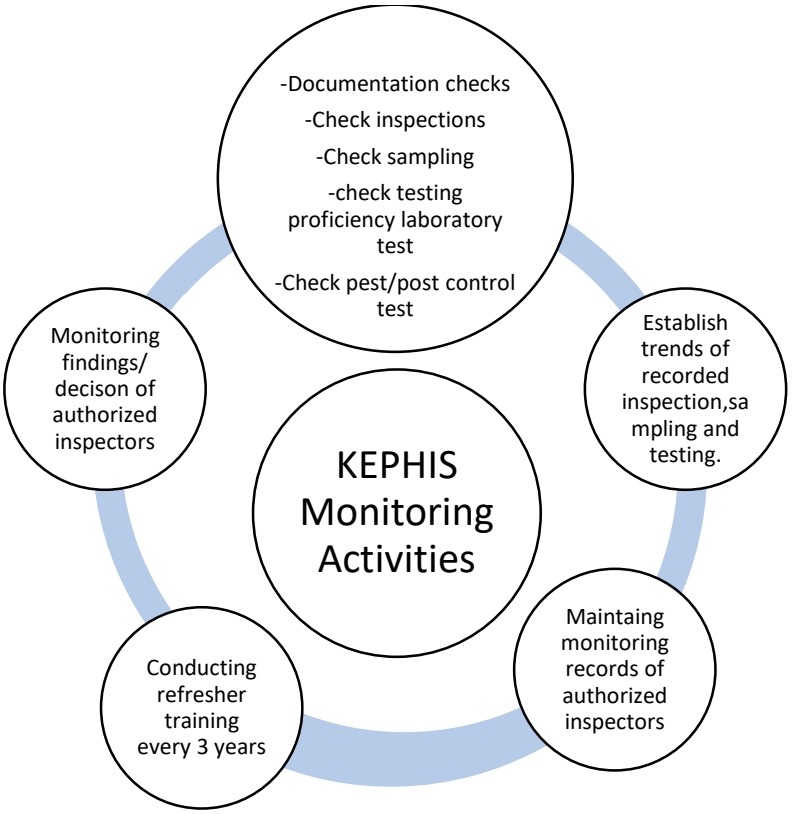


Figure 2.3: KEPHIS Monitoring Activities of Authorized Inspectors
Source: (KEPHIS 2017)

Seed companies have the leverage to select the seed inspector, sampler or analyst and they report to KEPHIS within 48 hours of seed certification (KEPHIS 2017). The seed inspector can examine any seed from any part of Kenya and request for any information (GoK 2012). KEPHIS provides checks for each authorized inspectors, sampler or analyst through re-examining some of their activities carried out (KEPHIS 2017). Every three years for those that are established, at least thrice a year for those that are new and withdrawal of license if conformity is less than 80% (KEPHIS 2017). Those that do not meet the minimum conformity, the seed inspector has the power to hold up the seeds

waiting for the court verdict (GoK 2012). Once found guilty the seeds are forfeited and disposed of (GoK 2012).

2.3 Conceptual Framework

2.3.1 Counterfeit Seed Model

Counterfeit occurs in economies where the supply of a good is fixed, and those with not enough supplies decide to undertake these activities (Nosal and Wallace 2007). Equilibrium does not exist in markets with counterfeits (Quercioli and Smith 2015; Nosal and Wallace 2007) and can only be achieved when the cost of counterfeiting is high (Shao 2014). The counterfeit activities occur in a few specific places in some irregular intervals in a certain type of a product (Nosal and Wallace 2007). This is made possible as there are no public records of the transaction on the sale of counterfeits from a specific person and dealers in genuine products cannot be identified (Nosal and Wallace 2007). The counterfeit model is built on several assumptions: (1) it is difficult to differentiate between genuine products from counterfeits, (2) imperfect information exits: owner/producer has more information than the other party, (3) products have a short shelf life, (4) products are expensive to produce, (5) there is no saturation point for counterfeiting, and (6) products are only traded a few times (Nosal and Wallace 2007). In the counterfeit model, the product of focus is money: genuine and counterfeit money. This model can be used to explain counterfeit seed market. All the above-stated assumptions by Nosal and Wallace (2007) and the imperfect inability of verification measures to dictate high-quality counterfeit are observed in this market.

The main finding by Nosal and Wallace (2007) is that investment in verification processes and increasing the cost of counterfeiting will deter counterfeiting. Based on the study, the fraudulent buyer does not imitate specialized/peculiar currency and attaches low value to holding the counterfeit money (Nosal and Wallace 2007). A study by Quercioli and Smith (2015) further supports the claim that investment in verification decreases counterfeit. The assumptions are similar (except assumption 3) and this study introduces a verification process. The number of transactions of the counterfeit product decreases for valuable products and verification is imperfect in identifying high-quality counterfeit (Quercioli and Smith 2015). The rate at which advances in counterfeiting occurs is at a higher rate than the verification progress (Quercioli and Smith 2015). Counterfeiting is restricted and stops when it becomes costly (earn zero profit or production of low-quality products that can easily be identified) and there is the free entry of players (Quercioli and Smith 2015).

2.3.2 Expected Utility

I use an expected utility model to analyze the behavior of individuals under risk. Utility is the satisfaction derived by an individual from consuming an economic good. Individuals maximize utility given the budget constraint. Presence of counterfeit seeds in the market has become risky to farmers as they are not sure of the quality of the product. They speculate the quality by looking at the product or after planting but this may not be the precise quality. WTP reflects the amount of money an individual is willing to pay for a commodity depending on the utility he/she gets from the commodity. A study by Ryan and

Spash (2011) found a strong correlation between attitude, behavior control, and norms of an individual with WTP and significance was only observed with norms and income.

A farmer maximizes utility when purchasing seeds (Eq. 2.1) given the amount of income set aside for seed purchases (Eq. 2.2). Eq. 1 shows the utility derived in a market with only genuine seeds. In the seed market with the presence of fake seeds, the farmer has no guarantee on the quality of the seeds. I assume that all the assumptions in the counterfeit seed market are observed. The utility will depend on the probability of buying fake seeds shown in Eq. 2.3. If the probability is high, the expected utility will be low and hence low WTP for seeds and vice versa. The expected utility function is based on Tamura (2005) using a cardinal utility function: X→ Re. The limitation of the expected utility model is that it cannot be used to model rare events with extreme and dire effects (Tamura 2005).

$$Maximize \qquad u(x_1, x_2) \tag{2.1}$$

$$\text{Given Budget Constraint } \; p_1 x_1 + p_2 x_2 \leq b \tag{2.2}$$

$$\text{Expected utility function } E(u,p) = \sum_{x \epsilon X} p(x) U(x) \tag{2.3}$$

Where u is utility, x_1 and x_2 quantity of seed A and B, p_1 and p_2 price of seed A and B, b the amount of income set aside for seeds purchases, X a set of consequences of buying seeds, $p = \{p_1, p_2\}$ is a set of probability for X (genuine or counterfeit seeds).

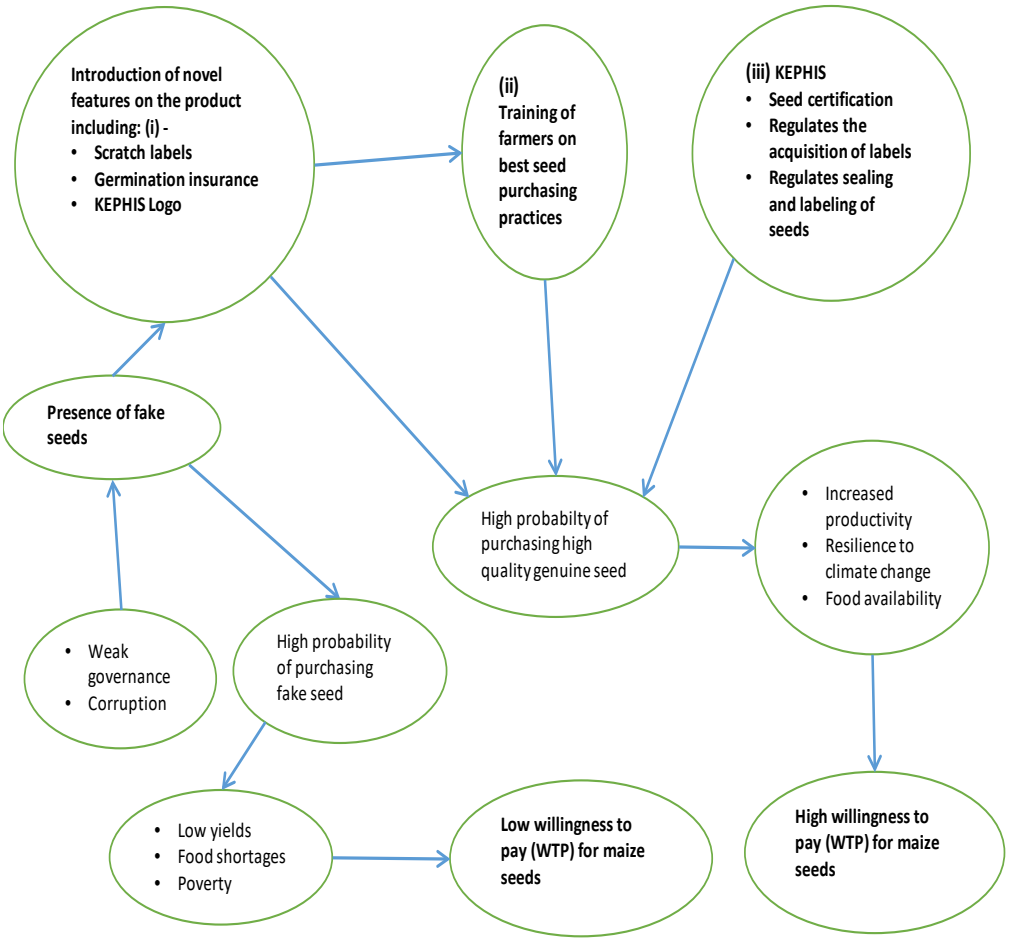


Figure 2.4: Impact of Fake Seeds and the Effects of Verification on WTP for Seeds

The diagram above explains the decision-making process of farmers facing constraints. Agriculture is very sensitive to any disturbance, and a small change can lead to significant impact especially among small-scale farmers. Adopting improved seed varieties is one way to increase agricultural productivity; however, with the current presence of fake seeds in the market, farmers have lost confidence. Figure 2.4, (i), (ii) and (iii) are verification measures that have been introduced to ensure the authenticity of

improved seed varieties. This research aims to understand the impact of the scratched label (certification codes) on the packet of the seed with a KEPHIS logo on farmers' willingness to pay for improved maize varieties and whether training on best seed purchasing practices has an impact on it. I also test whether farmers can distinguish tampered packets from untampered packets and whether or not they discount tampered packets. The perception, awareness, and experience of farmers in seed fraud were also be studied.

2.4 Hypotheses

Table 2.1: Hypotheses

	HYPOTHESES		RESULTS
1	There will be no difference in valuation between the different packets of improved maize seed varieties.	Ho: $WTP_{\text{tampered multiple source packets}} = WTP_{\text{untampered multiple source packets}} = WTP_{\text{untampered seed company packets}}$	Reject. Farmers have a higher WTP for untampered seed company packets with no differences between tampered multiple source packets and untampered multiple source packets.
2	Provision of information about best seed purchasing practices will not change farmers' perceptions when buying maize seeds nor their WTP for maize seed packets that have been tampered with.	Ho: $\omega_{\text{Training(video)*seed}}=0$	Reject. Provision of information about best seed purchasing practices will change farmers' perceptions when buying maize seed and have a negative influence on their WTP for maize seed that has been tampered with.
3	The difference in trust between the seed company and agro-vet has no effect on the WTP for the seed company untampered packet.	Ho: $\gamma_{\text{Difftrst*WTP untampered seed company packet}}=0$	Cannot reject.
4	The extreme concern of counterfeit seed has no effect in WTP for maize seed packets.	Ho: $\gamma_{\text{Conc\_countseeddum}}=0$	Cannot reject.

Chapter 3

METHODOLOGY

3.1 Study Design

Western Kenya farmers have a negative perception of improved maize varieties (Odendo et al. 2002) and low use of hybrid maize seeds (Smale and Olwande 2014). I purposely selected Homabay county and Bondo in Siaya county as Duma 43 maize variety is the widely grown variety which is the main focus of the research. This is based on a collected data by Tegemeo Institute of Agricultural Policy and Development (2013). For each county, two sub-locations were randomly selected: (1) Bar Kowino and (2) Nyawita in Bondo, and (1) Nyatoto and (2) Gongo in Homabay. This was done by numbering all sub-locations in the county and using a random number generator application to generate two random numbers to represent the selected sub-locations. The same procedure was used to select two villages in each sub-location: (1) Matangwe and (2) Udimba in Bar Kowino; (1) Nyokwany and (2) Nyariaro in Nyawita; (1) Nyabera and (2) Wang'neno in Nyatoto; and (1) Nyawaita and (2) Ogande in Gongo. In each village, a complete list of households that carry out farming was obtained from the village elder, and thirty-five participants were randomly selected. This was done by generating random numbers in STATA that selected thirty-five participants and dropped the other households on the list. In total two hundred and sixty-four participants were interviewed, resulting in an 88.1% response rate. This

occurred because of relocation, unavailability, and some of the participants who were independent households during sampling had become part of another household in the sample therefore considered as one. I did replacement by selecting households within the complete list depending on availability.

There were five sessions a day in each village: 9:00 a.m. to 10:30 a.m., 10:30 a.m. to 12:00 p.m., 12:00 p.m. to 1:30 p.m., 1:30 p.m. to 3:00 p.m., and 3:00 p.m. to 4:30 p.m. These sessions were conducted in the village meeting point (e.g. church or school) and the participants were informed prior to the day of the study by the village elder including the session number, time, and told to bring a mobile phone to the session. Some of the meeting places were on an open field and others enclosed rooms. Participants were assigned to five sessions in ascending order according to the list: the first seven participants were in session one, the next seven in session two and this was done until the list was exhausted. In each village, participants were grouped into two. Half of the participants (those in the 2 or 3-afternoon experiments) received information about best seed purchasing practices. To balance the training in each sub-location, the first village interviewed had two training sessions and three sessions were conducted in the second village. Two villages shared a boundary; therefore, I conducted the session from the two villages with no training on the first day and the following day I conducted the training session. This was done to ensure that there was no spillover effect on the control group.

3.2 Economic Field Experiment and Becker-DeGroot-Marschak Mechanism

In experimental economics, a researcher has control of extraneous factors through the reaction of participants to know how they behave in a given setting while controlling

for other variables in the model and using randomization. Experimental economics is able to sort out the cause and effect when many variables are changing simultaneously and can either be a lab experiment or a field experiment. Experimental economics can be used to test the efficiency of a program and policy, understand how people make decisions in response to these, and how they interact with the policy and between themselves. It can also be used to predict the effects and benefits of the program or policy and how it can be improved to come up with better and in some cases cost-effective policies. In this study, I used a framed field experiment. It is characterized by (1) informed subject pool about the product, (2) occurs in natural environmental setting, (3) use available product with substitutes, (4) informed subject on the task in the experiment, and (5) involves some stake to the subject as they care about the task (Harrison and List 2004). The advantages of field experiments are high external validity, more realistic, used to study complex problems, and flexibility and applicability in the wide category of problems. Its limitations are that field experiments are expensive and time-consuming. A survey can be used to supplement experimental data by obtaining information on characteristics and perception of participants so that researchers can control for these factors in their economic analysis (Harrison and List 2004). Surveys eliminate overgeneralization, ensure reliable reasoning and arriving at a valid conclusion about the social world as participants are randomly selected.

Experimental auctions can be used in economic experiments to estimate WTP. Experimental auctions are incentive compatible as participants bid real money for real products. Compared to experimental auctions, stated preference tends to be sometimes

unrealistic for existing products in the market as participants tend to overstate the value of products (De Groote et al. 2016; Hossack and An 2015; Kimenju et al. 2005; Ryan and Spash 2011). Occasionally the revealed preference may not reflect the optimal interest of an individual. This can result from the complexity of the decision, the number of options available, the effects of the decision are not immediately felt, lack of knowledge about the decision, and persuasive marketing of products (Ryan and Spash 2011; Beshears et al. 2008). Economic theory predicts that market prices increase as demand increases and valuation of a good decrease with negative information (Lusk and Hudson 2004). Various studies have been carried out in Africa with different experimental auctions using different products, e.g. Kiria, Vermeulen and De Groote (2010) studied quality protein maize in Tanzania using Becker-DeGroot-Marschak Mechanism (BDM) while Morawetz et al. (2011), and De Groote and Kimenju (2008) used it in Kenya.

BDM was used to estimate WTP for this study. It works like a second-price Vickrey auction; participants submit bids and the win depends on how the stated bid relates to the random offer price. A person only wins a bid if the stated bid is higher or equal to the random offer price but pays the random offer price. The population is spread and with few products, BDM can easily be carried out during household interviews with no spillover effect (De Groote, Kimenju and Morawetz 2011; De Groote et al. 2016). In spite of BDM mechanism being expensive, time-consuming, and difficult to conduct, it can generate a more realistic preference estimate with the stated WTP close to the true value (De Groote et al. 2016; Kimenju et al. 2005). Limitations of using the BDM mechanism are that (1) the mechanism is difficult to explain, (2) participants tend to be confused with paying the

random price and not the stated price, and (3) the order in which products are presented may influence their WTP (Morawetz and Kimenju 2011).

The experimental auctions need to take into account differences in participants, their market experience, and income (Morawetz and Kimenju 2011). Participants are provided with cash including show up fee as most African rural participants tend to be poor and providing them twice or 50% more than the price of the known product prevents overbidding compared to offering more, to cover costs, avoid truncation issues and harmonizes the method across experiments (De Groote et al. 2016; Morawetz and Kimenju 2011; Hossack and An 2015). Only a single round is selected in various studies to be binding to reduce costs and payment in the practice rounds tends to be lower or not at all compared to main session to reduce the effect of cash in hand on the valuation of subsequent rounds (Morawetz and Kimenju 2011; Becker, DeGroot, et al. 1964; Lusk et al. 2001). Open-ended bids are the most preferred as it requires a smaller sample compared to dichotomous choices (where a participant make a choice whether to buy at the stated price) which is biased depending on the starting point (Halstead, Lindsay and Brown 1991).

3.3 Experimental Design

An economic field experiment was designed to (1) estimate farmers' WTP for packets of maize seed with different attributes, and (2) test the impact of an information treatment on farmers' WTP. An open-ended BDM mechanism was used to elicit participants' WTP (Becker, DeGroot and Marschak 1964). The experiment included both within-subject and between subject treatments using a 6x2 design as shown in Table 3.1. Participants bid on six different packets of maize (within-subject), and half of the

participants received the information treatment (between-subject). To ensure that farmers were bidding on seeds that they would be interested in buying, each farmer was asked to choose between two popular different seed varieties in the study area at the beginning of the session – Duma 43 and DK 8031.

Table 3.1: Experimental Design

		Information treatment: Seed purchasing best practices (between subjects)	
Selected seed[a] (within subjects)	Multiple sources untampered packet (U. multiple sources)	No(T1)	Yes(T2)
	Multiple sources tampered date packet (T. date)		
	Multiple sources scratched label packet (T. scratch label)		
	Multiple sources tampered packet seal (T. packet seal)		
	Seed company untampered packet (U. seed company)		
	Traditional seed variety (Traditional)		

[a] Selected seed is either Duma 43 or DK8031

The seed packets were obtained from multiple sources. U. seed company was obtained from the seed company (Duma 43) and an outlet of the seed company (DK 8031) that packages the maize seeds in smaller packets. U. multiple sources, T. date, T. scratch label, and T. packet seal were obtained from multiple agro-vets where farmers purchase

seeds from. U. seed company and U. multiple sources were untampered packets while T. date, T. scratch label, and T. packet seal the packet were tampered with. The packaging material and seal were different for the two variety of maize seeds. Duma 43 packet had a paper packet and it was sealed with a white stitch and at the agro-vet shops some of the packets the stitches were broken and I mimic this for T. packet seal. The DK 8031 packet was a plastic packet, it was completely sealed with a heat sealer and a small impact on the packet breaks the packet seal on the side I imitated this for T. packet seal and sealed it with a clear cello tape. Movement of packets within the shops leads to some of the packets the scratch label to be completely scratched, and I did this for all the T. scratch label packets for both varieties. For T. date, I tampered with the digits in the date by using a black marker pen and ensuring all the digits had the same font and thickness. The traditional packet was a brown paper packet with two kilograms of traditional seed: the variety varied depending on the area. Table 3.2 summarizes the description for each seed packet.

Table 3.2: Description of Maize Seed Packets

Seed Packet	**Description**
U. multiple source packet	It is an untampered packet purchased from any of the agro-vet shops in the shopping centers close to the villages.
T. date	It is a tampered packet with the date digits altered to a more current date e.g. 2016 to 2017.
T. scratch label	It is a tampered packet with the scratch label completely scratched off.
T. packet label	It is a tampered packet with a broken seal in any side of the packet.
U. seed company	It is an untampered packet purchased from the seed company or an outlet of the seed company.
Traditional	It is an open packet of traditional maize seed variety. This seed is sold in an open container in the marketplace.

3.4 Experiment Procedure

There were two parts in each session, part one was a practice part using candies to make sure farmers understood the BDM mechanism. Part two was the main part using maize seeds. A two kg packet of seed was used for the study as it is the common quantity in which farmers purchase seed and readily available in the agro-vet shops. Payment for participants was KES 10 ($ 0.1) for part one and KES 900($9) in part two twice the value of maize seeds and candies. Five sessions were carried out per day in each village with each consisting of six participants with overlap between the sessions to avoid communication between participants. An experiment lasted approximately 45 min and was conducted in a central location in each of the eight identified villages in Nyanza Province, Kenya.

The field experiment was conducted with the help of enumerators. Six enumerators were selected, conversant with the local language (Luo) and underwent a rigorous one-day training in the experimental design and survey before data collection, which lasted eight days. Participants that were allowed in the study were either head of the household or the spouse or in their absence someone eighteen years and above who have been part of the household for more than one month and knowledgeable about agricultural activities of the household. Siaya was the first sub-location to be studied and I conducted a pilot study in Bondo in a different sub-location, Ajigo and interviewed thirty-five participants in Lwala village. This was done to ensure that enumerators understood the BDM mechanism, the experiment instrument worked, and to know how long each session lasted.

Before the start of the experiment, each enumerator was paired with a participant and randomly assigned an identification number. The enumerator explained to the participant the purpose of the study, confidentially of their responses, and the participation payments before obtaining consent. They were told payment will be in form of MPESA (phone-based money transfer) paid out at the end of the session including service charges (cover cost of the transaction) and the amount will depend on the purchases made. MPESA was used as it safe, reliable, trustable, and eliminates the bulkiness of carrying currency in small denominations. The enumerator then established the maize choice of the participant and took a tablet and a pair of headphone. They sat on chairs close to each other, and not in close proximity to other participants to ensure that they could not hear each other. At each part, after each participant had disclosed their WTP they moved to the centre of the room and selected the binding products before going back to continue with the interviews.

At the start of the experimental session, participants watched a short video of instructions in their local language (Luo) and given an opportunity to ask questions. The video was used for consistency of information. It was a recording of a person reading out instructions translated from English to Luo displaying the candies and dice to be used. The first part consisted of three different types of candies labeled A, B, and C. The number of candies for a practice round is similar to the study by De Groote et al. (2016). Candies were picked up in a random order and each participant was allowed to inspect the candy and asked to state the maximum price they are willing to pay for each. Only one type of candy was randomly selected to be binding by choosing one of the three white envelopes (Figure 3.1) by one of the participant in the session, someone else opening the envelope, and

displaying the card in it. The distribution of the envelopes was one card for each type of candy. The participants had the chance to revisit their choices and change their bids before the binding candy was generated at the end of the part.

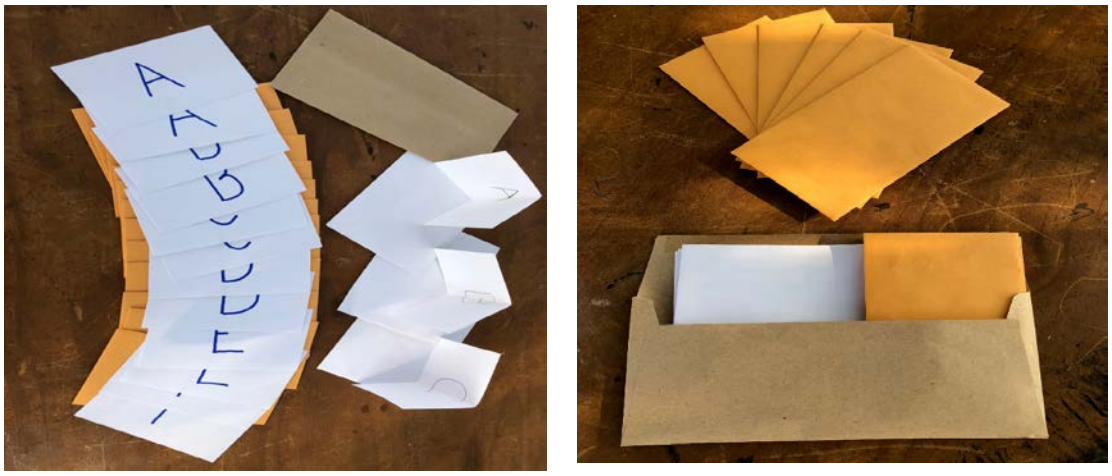


Figure 3.1: Distributions of Envelopes in the Experiment Session

The actual purchase depended on whether the randomly selected price was no greater than the price at which the participant said they would buy the candy. The random price was generated by each of the participants through rolling a green 10-sided dice having values from 0 to 9 after selection of the binding candy. If the participant indicated that she/he would buy the candy for the randomly selected price, then the exchange took place. He/she was given the candy and the stated random price was deducted from the payments at the end of the session. If he/she was not willing to pay that price for the candy, then no exchange took place.

Part two consisted of six packets of seeds and only a single product was binding. Participants were asked to bid based on either Duma 43 or DK8031. Information was relayed to the participants that the seeds have been sourced from different suppliers except for U. seed company and part one and part two are independent, and the decision in part one does not affect part two. The six packets (untampered packets: U. seed company and U. multiple sources and tampered packets: T. date, T. scratch label, and T. packet seal) were laid down on the ground in front of the participants including the traditional variety.

At the start of part two, the participants watched a short video of instructions in Luo and given an opportunity to ask questions. It was a recording of instructions translated from English to Luo displaying the packets of maize seed (Figure 3.2) and three dice to be used: blue, green, and red. The training group watched an additional video afterwards. It was a video on how to purchase seeds and what to look for in the seed packet (pointing out the exact position in the seed packet) before the purchase to ensure the seed is genuine. The best seed purchasing practices information was obtained from KEPHIS and the constitution of Kenya website. It stated (1) what farmers should check for when purchasing seed; (2) what features a seed packet should contain; and (3) what to do in case they suspect the seed is a fake. I did not disclose the source of information to farmers to avoid any kind of biasedness. The guidelines are attached in the appendices. Seed packets were picked up in a random order and each participant was allowed to inspect the packet and asked to state the maximum price they are willing to pay for each. The packets were labeled A to F (A: U. multiple sources; B: T. date; C: T. scratch label; D: T. packet seal; E: U. seed company; and F: traditional) at the back to identify each packet when inputting the data. They had

the chance to revisit their choices and change their bids before selection of the binding seed packet.

Figure 3.2: Display of Five Seed Packet of Improved Varieties from A-E.

The random price for part two was generated with three 10-sided dice with 0-9 in blue for the first digit, green for the second digit and red for the third digit for all the sessions. In case the first digit was a nine, the participant had to roll again to ensure that the 3-digit number is between 0 and 899. The binding maize seed packet was randomly selected by choosing one envelope from six envelopes by one of the participants in the session, someone else opening the envelope and displaying out the card. The distribution of the envelopes was two cards for each of seed packet. In each session, I randomly selected six envelopes out of the twelve envelopes. The actual purchase depended on whether the randomly selected price was no greater than the price at which the participant said they would buy the packet of seed. If the participant indicated that she/he would buy the packet of seed for the randomly selected price, then the exchange took place. He/she was given the packet of seed and the stated random price was deducted from the payments at the end

of the session. If he/she was not willing to pay that price for the packet, then no exchange took place.

The survey was conducted immediately after the experiment, which took approximately thirty minutes. Data were collected on farmer characteristics, agricultural practices and awareness and perception of seed fraud. This provided background information about the farmers and the parameters to be used in the Tobit model. At the end of the survey, the participant and the enumerator calculated the payments. Participants were paid KES 910 minus stated the random price in part one (practice) and part two (experiment). If no exchange took place in either of the parts, the participant received KES 910 by MPESA plus the service charges (which is deducted at the time of withdrawal of money from the MPESA account) otherwise purchased made was deducted and transferred the balance with the service charges.

3.5 Empirical Model

Tobit models are used when we expect the dependent variable will have clustering/truncation at zero (limiting value) but it can take any non-negative value. This type of model is suitable for my bid data because all bids were non-negative, and 5% of bids are stacked at zero. The advantages of using this model are that it uses all the data to compute the regression line compared to other methods that ignore the limiting value that leads to biased and inconsistent estimates (McDonald and Moffitt 1980; Halstead et al. 1991). Compared to OLS, Tobit model enables the estimation of the effect of explanatory variables on zero bids and the probability of them shifting to non-zero bids based on changes on the explanatory variables (Halstead et al. 1991). The predicted values may not

be within the upper and lower limits of the study (Ashour et al. 2017). The Tobit model used in this paper is shown below. Bids for the seed packets, y_{ij}, are modeled as,

$$y_{ij} = \begin{cases} y* & if \quad y* > 0 \\ 0 & if \quad y* = 0 \end{cases}$$

where $i = 1, \ldots, N$ represents the subject and $j = 1, \ldots, 5$ represents the type of seed packet.

y_{ij} linearly depends on a set of variables and expressed as follows:

$$y_{ij} = \alpha + \boldsymbol{\beta Treatment}_{ij} + \boldsymbol{\delta Training}_{ij} + \boldsymbol{\omega}(\boldsymbol{Treatment}_{\boldsymbol{ij}} \times \boldsymbol{Training}_{ij}) + \boldsymbol{\phi SEED}_{ij} + \quad \boldsymbol{\gamma X}_{ij} + \boldsymbol{\varepsilon}_{\boldsymbol{i}} + \boldsymbol{e}_{ij}$$

where α is the average bid of the entire population, ε_i is individual random effects, and e_{ij} is the error term for individual $_i$ for product $_j$. The variable $treatment_{ij}$ (untampered multiple source packet, untampered seed company packet, multiple source tampered date, multiple source scratched label, and multiple source tampered packet seal), $seed_{ij}$ (Duma 43 and DK8031) and $training_{ij}$ (training on best seed purchasing practices) are dummy variables and $training_{ij}$ and $treatment_{ij}$ is an interaction term for training and treatment. X_{ij} in Table 4.9 represents sociodemographic, economic, and Table 4.10 are the cognitive characteristics.

Chapter 4

RESULTS

4.1 Demographic, Socio-Economic and Farming Characteristics

264 people participated in the experiment. The sample consisted of 61.5% females and 58.4% of the female participants were household heads. Almost three-quarters of the respondents were household heads, 25.2% were spouses of which most were female (24.1%) and the rest (2.7%) were children, parents and son/daughter in law. Table 4.1 shows the composition of respondents based on gender. Education is normally distributed, with the mean level of education being 7.4 years, 46.6% of the total sample. It ranged from 0 years to 16 years of schooling with preschool considered as 1 year of schooling. All male respondents had 2 or more years of education as opposed to 16.8% of the female respondents who had no schooling.

Table 4.1: Relationship to the Household Head Based on Gender

Percentage of participants			
	Male (%)	Female (%)	Total (%)
Head (main decision maker)	36.26	35.88	72.14
Spouse	1.15	24.05	25.19
Child (daughter/son)	0.38	0.00	0.38
Parents	0.76	0.76	1.53
Son/daughter in law	0.00	0.76	0.76
Overall	38.55	61.45	100.00

In a previous study on farmers in Siaya county, the percentage of females was 72% and 70.4% in western Kenya (De Groote et al. 2011). In a study by De Groote et al. (2016) on all major maize growing areas, the percentage of female participants was 61% (in 2009) compared to another study where 43% were women (Wainaina et al. 2016). Female-headed households represented between 19% and 21% of participants (De Groote et al. 2016; Wineman et al. 2017). There has been an increasing level of female-headed households reaching 27% by 2010 (Mathenge et al. 2012) from 21% in 2007 (Smale and Olwande 2014).

Agriculture is the main source of livelihood, almost half of the participants depend on it. In the main season 98.5% farmers planted maize but 91.2% in the short season. 44.4% retained the same acreage (between 0.125 – 22 acres) in both seasons, 43.2% planted less acreage in the short season while the rest increased the acreage. A strong positive correlation existed (0.8) between the acreage in the main season and short season. More of owned land was planted by farmers than rented land in both seasons.

More improved maize seed variety was planted in the main season compared to the short season, in which they planted more of the local variety. There was an additional number of maize seed varieties in the main season than in short season. The maize seed sector was dominated by two varieties, Duma 43 from Seed Co and DK8031 from Monsanto as shown in Figure 4.1. The top three reason farmers selected the varieties are drought tolerance, high yields, and early maturity which reflects the inadequate rainfall experienced in the area as displayed in Table 4.2.

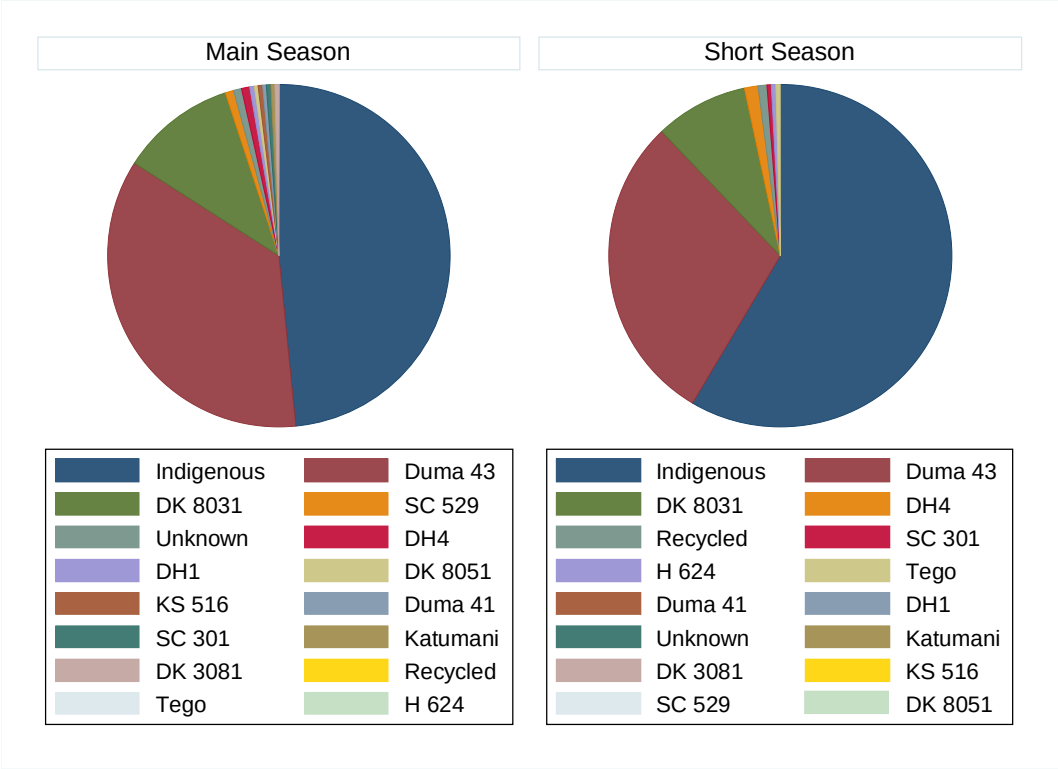


Figure 4.1: Maize Seed Varieties Planted in the Cropping Year 2017

Table 4.2: Reasons for Selection of Maize Seed Variety

	Duma 43 (%)	DK 8031 (%)	Overall (%)
Drought tolerance	34.30	22.40	32.10
High yielding	28.20	30.60	28.60
Early maturity	21.10	14.30	19.80
Maize plant and grain attributes	8.00	20.40	10.30
Habit	3.30	0.00	2.70
Experiment on the variety	1.90	6.10	2.70
No reason	1.40	0.00	1.10
Taste	0.50	2.00	0.80
Heard of it from e.g. radio	0.90	0.00	0.80
Dislike negative trait of Duma 43	0.00	4.10	0.80
Availability	0.50	0.00	0.40

The percentage of improved maize seed varieties grown is more in the main season than the short season. It was 51.2% in the main season, 69.7% Duma 43 and 21.2% DK 8031. In the short season, 41.4% planted hybrid varieties, 70.7% Duma 43 and 21.2% DK 8031. The other varieties were less than 5% in both seasons. This is depicted in Table 4.3 by the percentage increase of local seed from own seed (6%), from farmer/neighbor (1%), and general market (3.5%) and a decrease of hybrid seed from agro-vets (1.8%,) small trader, (7%) and the other sources. Farmers had no unique response to the sources of seeds. The four major sources are stockists, general market, own (recycled) seed, and small traders. Almost half of the participants purchase seeds from the stockists and small traders in the main season and about 40% in the short season. Very few farmers acquire seeds directly from the seed company.

Table 4.3: The Source of Seed in the Maize Cropping Year 2017

	Percent of participants		Percent of Cases	
	Main Season (%)	Short Season (%)	Main Season (%)	Short Season (%)
Stockists / agro-vet	26.37	24.62	29.84	27.2
General market	21.92	25.38	24.81	28.03
Own seed	20.89	26.89	23.64	29.71
Small trader e.g. kiosk	19.86	12.88	22.48	14.23
Farmer/neighbor	5.82	6.82	6.59	7.53
NGO/CBO	2.05	1.89	2.33	2.09
KFA	1.37	0.76	1.55	0.84
GoK	0.68	0.38	0.78	0.42
Seed company	0.68	-	0.78	-
Unknown	0.34	0.38	0.39	0.42

4.2 Farmers Past Experience and Perception on Fraudulent Seed

Fraudulent seed reported cases was high, with almost half of the respondents either purchasing fraudulent seed or hearing about someone else purchasing it. Nyokwany and Ogande village had high rate experience with fake seed, where 25.7% perceived they had purchased fraudulent seeds with 34.3% and 28.6% respectively hearing it from others. Matangwe recorded the lowest incidence with 38.7% buying or hearing of fraudulent seeds, the other villages being between 40%-60%. Small trader i.e. shops and kiosk had the highest percentage (44%) of cases twice the rate of agro-vets and general market. Only the seed company had no incidence. The farmers that purchased fraudulent seeds, was mostly within a month before planting season or after planting season (more than 40% each). Merely 14% purchased it more than a month after planting. Table 4.4 presents farmers past experience, source, and timing of the purchase of fake seeds.

Table 4.4: Farmers Past Experience in Seed Fraud (N=262)

Information on past experience on fraud		
	Number of participants	Percentage
Experience		
No experience with fraudulent seeds	134.00	51.15
Purchased fraudulent seed	50.00	19.08
Only heard of others purchased fraudulent seeds	78.00	29.77
Source		
Small trader	22.00	44.00
Stockists/agent/agro-vet	12.00	24.00
General market	12.00	24.00
NGO	1.00	2.00
KFA	1.00	2.00
Farmer/neighbor	1.00	2.00
GoK	1.00	2.00
Timing		
More than 30 days before the beginning of planting season	7.00	14.00
1 to 30 days prior to planting season	22.00	44.00
After the start of the planting season	21.00	42.00

*Farmers did not know they bought fraudulent seeds.

Farmers were asked to list all features that made them suspect the seed was a fake. They mostly attributed fake by looking at the germination rates (43.8%) and yields (33.8%) displayed in Figure 4.2. Some farmers looked at the appearance of the maize plant and grain to tell the authenticity of the seed (7.5%) and the rest 15% constituted preventive measures. These measures were packaging design, the dye of the seed, expired date and KEPHIS logo that are among the best seed purchasing practices outlined by KEPHIS. Best seed purchasing practices protect the farmer from economic losses and food shortages that

might arise from the purchase and planting of fraudulent seeds. However, on a packet of maize seeds, the only available information is sampling date and not the expired date. Unless a farmer knows how long the validity certificate remains valid (one year from the sampling date) this does not verify the authenticity of the seed.

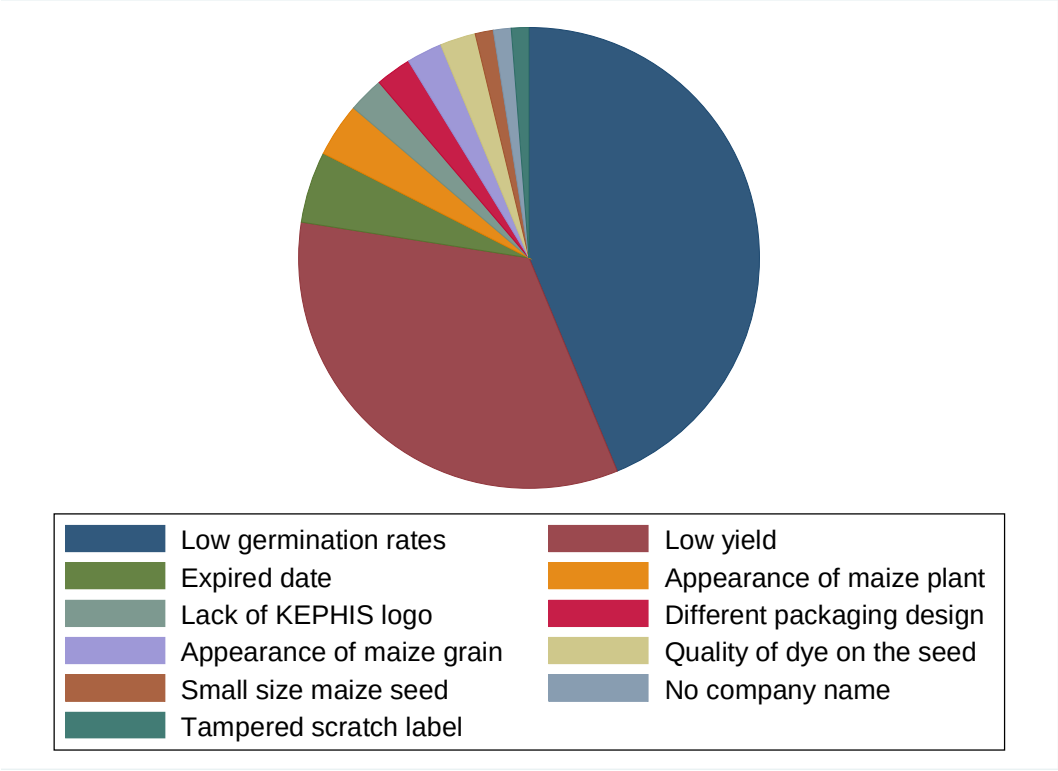


Figure 4.2: Attributes of a Counterfeit Seed as Experienced by Participants

Does past experience with suspected fake seeds by farmers make them fear the presence of fake seeds in the market? Farmers were asked how concerned they are about the constraints in Figure 4.3 affecting agriculture without rising suspiciously on fake seeds. Farmers are more concerned about insect, diseases, and rainfall. Farmers adopted drought

resistance maize varieties with over 50% having the perception it will still have a significant impact. Fraudulent and counterfeit seed is in the fourth position followed by low-quality seeds. Some farmers believed it will not affect them in future: 44.0% of those that have never heard of fraudulent seeds, 9% those that heard of it, and 6% for those that purchased it. Farmers that planted a hybrid seed in the short or main season had a higher level of concern than those that only planted local variety. Overall 32% of the farmers are a concern it will have a huge impact on their maize production. The other issues are less than 10% that it will intensely affect them with more than 50% of farmers viewing it as slightly affecting them or not at all in the future.

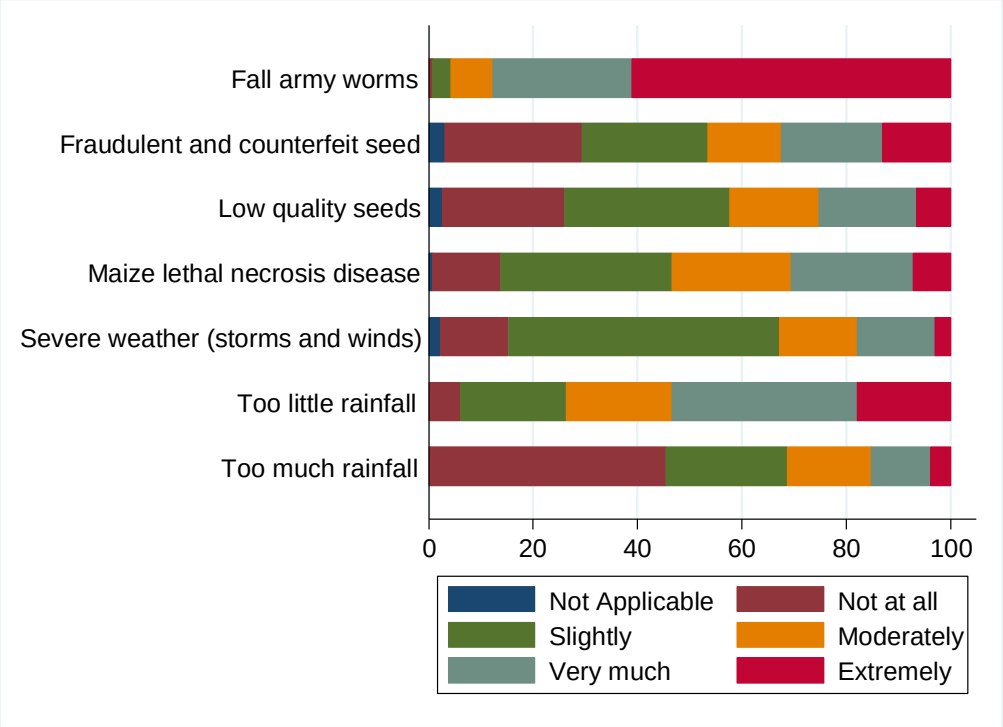


Figure 4.3: Level of Concern for Various Constraints Affecting Maize Production *
* Not applicable means the farmer does not observe the constraint

4.3 Seed Purchasing Practices Used by Farmers for Quality Assurance

The presence of fake seeds in the market has resulted in a different trust level for the various sources of seeds. Looking at the different sources of seeds, the seed company has the highest trust level compared to other sources in the provision of high-quality genuine seed apparent in Table 4.5. However, this is the least common outlet of seed by farmers, less than 1% of the farmers purchase seed from the seed company as indicated in Table 4.3. Agro-vets are the most common maize source, and only 33% extremely trust this source. Checking for seed merchant license is one way of increasing trust of these sources but most farmers (79%) do not practice that.

Table 4.5: Level of Trust for Different Sources of Improved Maize Seeds

Level of trust for different sources for the provision of high-quality genuine seed from 1-Not at all to 5-Extremely			
Seed merchant	Participants	Mean	Std. Dev.
Seed company	254	4.72	0.6
Stockists/agent/agro-vet	253	3.96	0.89
GoK	246	3.81	1.2
KFA	189	3.65	1.17
NGO	232	3.56	1.21
Farmer Group	248	3.17	1.20
CBO	218	2.91	1.25
Small trader	257	2.45	1.2
Farmer /neighbor	249	2.37	1.28
General market	250	2.06	1.11

* The number of participants differ between groups as some of the respondents are unaware of this sources and cannot make a judgment on it.

Farmers were asked to list all features they consider when buying seed to know if it is of high-quality genuine seed which is presented in Table 4.6. Most farmers do not purchase seeds blindly, only 4.1% did not verify the seed. They have a wide criterion to look for when purchasing seeds. The most used verification method is checking for a valid date (19.7%). Some farmers (16.2%) bought a specific variety thinking that because of previous knowledge of how the seed performed it will not disappoint them. Attributes of the maize seed (8.8%) and germination rate (7.5%) were also considered. Some practised preventive measures that include (5.8%) buying early in the season and considering the type of the seed merchant. The rest (8.8%) are only suspicious if the prices and weight are not within the normal range.

Table 4.6: What Farmers Look for to Ensure High-quality Genuine Maize Seeds

	Frequency	**Percent of participants**
Valid date	105.00	19.74
Buying specific variety	86.00	16.17
Packet design	78.00	14.66
Intact packet seal	46.00	8.65
Normal price range	41.00	7.71
Germination rate	40.00	7.52
Dye of seeds	22.00	4.14
None	22.00	4.14
Type of seed merchant	20.00	3.76
The appearance of the maize seed	25.00	4.70
KEPHIS logo	15.00	2.82
Unscratched label	12.00	2.26
Purchase early in the season	11.00	2.07
The weight of the maize packet	6.00	1.13
Lot number	2.00	0.38
Kenya Bureau of standards logo	1.00	0.19

Almost 55% of farmers read instructions on a packet of seed, but most do not notice the new features on a packet nor do they try it out the moment they become aware of it. Scratch labels have been introduced to protect farmers from counterfeit seeds. Only 16.8% are aware of seed certification labels, of which 61.4% have never used this service before, 13.6% once, 13.7% a few times and only 11.4% every time they purchase maize seeds. Reading instructions on the packet of seed reveals important and new information about the maize seed. The level of education is not a restriction for farmers as more than 66% of the farmers interviewed had 7 years and more years of schooling. According to Mburu et al. (2010) an average of 6.4 years of schooling is a high literacy level and the farmer can understand information about improved maize seeds. Only 11.9% of those (45% of the total sample) that have never read instructions were aware of seed certification labels.

Inspecting the seed packet is the first point at which farmers can identify high-quality genuine seed. Respondents were asked to choose between two types of packaging material; paper and plastic packet and the reasons for selecting it. This question was asked to see if farmers relate packaging to identifying high-quality genuine seed. About two-thirds of the participants preferred paper with only 37.4% opting for the plastic packet. Farmers preferred a type of packaging that could not easily be tampered (13.7%), with most considering the viability of the seed (Figure 4.4). Less than 1% did not consider any feature and 4.1% being habitual. The plastic packet is mostly selected because it is water resistant. Paper packet was chosen because it's not easily damaged by either movement or storage. Farmers also considered the ability of the packet to be unaffected by pest and its attractive appearance. Specific traits of the packet design also played a role. Farmers liked plastic

packet because it allowed them to see the seed. Paper packet was preferred because of its material, it is unaffected by moisture, heat or sunlight and biodegradable compared to the plastic packet.

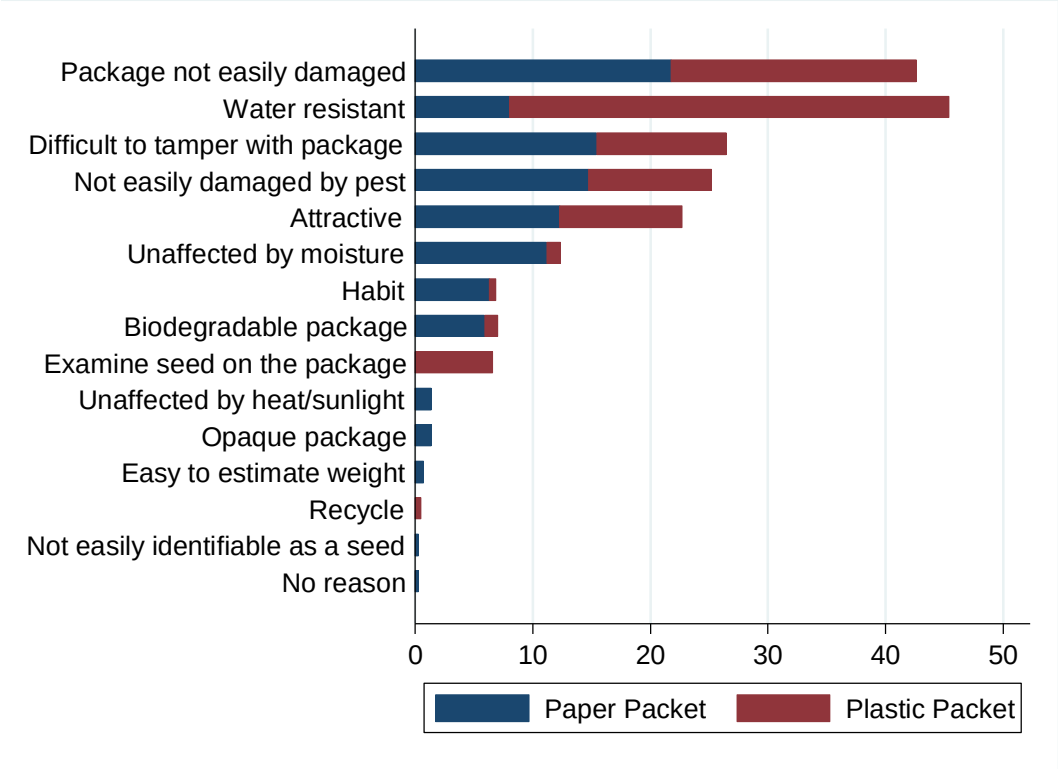


Figure 4.4: Reasons for the Preference of Packaging Material for the Seed Packet

After the experiment, participants listed all sources from which they had received training on best seed purchasing practices. Most farmers had not received any information or training before the study (Figure 4.5). This implies that farmers were making a purchase decision based on intuition and they had no knowledge of protecting themselves from the purchase of fraudulent maize seeds. The two common source of information was the radio

and NGOs that had a presence in these areas. The other sources listed by farmers are relative. Input dealers are in the sixth position. The sources farmers can get up to date information and advice on agricultural issues make up 14.5%.

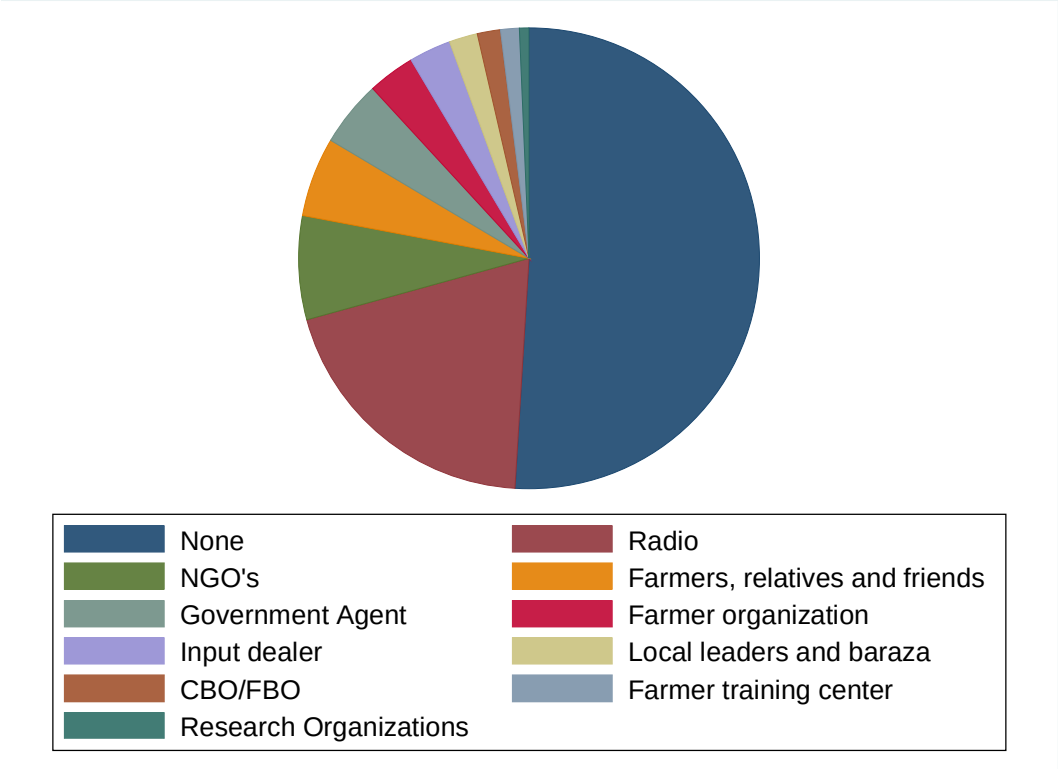


Figure 4.5: The Source of Information/Training on Best Seed Purchasing Practices

Following recommended best seed purchasing practices enables farmers to identify fake seeds. Farmers also stated their reactions when they realized they had purchased counterfeit seed. The two main responses (Figure 4.6) by farmers were to change the maize seed variety (24.2%) and to change point of purchase (19.7%) as they did not decipher as the presence of counterfeit seeds in the market. One of the other options for them is to

return the seed at the point of purchase and request another packet (16.7%). About 15% will report to the relevant authorities. This explains why there are a few recorded cases. The risk-averse farmers opt to plant local varieties only (14.1%) while some are willing to accept a lower level of risk by reducing the amount of improved varieties purchased in future (4.5%) and 3.3% not sure of the action they will take. Maize is the common food crop in the area and farmers did not consider planting other crops as an option (only 0.2% opted for this) and even a few farmers will go ahead to plant the variety (0.8%).

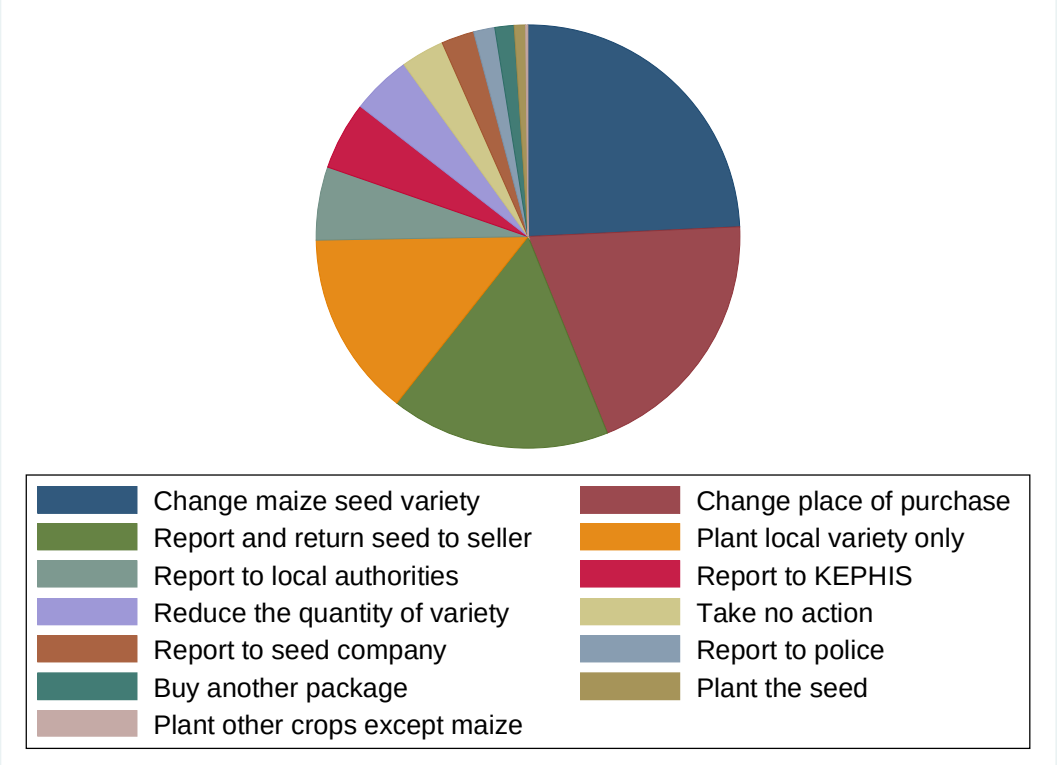


Figure 4.6: Action in Response to the Purchase of Counterfeit Seed

4.4 WTP for Various Maize Seeds Packets

WTP for intact improved varieties packets is higher compared to tampered packets. Farmers bid on five improved maize packets of their choice (either Duma 43 or DK8031) and a local variety, 81.3% selected Duma 43 the other 18.7% selected DK 8031. The improved maize packets are two untampered packets (U. multiple sources and U. seed company) and three tampered packets (T. date, T. scratch label, and T. packet seal). The packets were displayed in a random order. The average WTP for improved maize variety is greater for U. seed company (KES 462.94) sourced from the seed company compared to multiple sources seed packets as illustrated in Figure 4.7: uppermost WTP is from U. multiple sources (KES 402.44) followed by T. date (KES 396.91), T. scratch label (KES 385.87), and T. packet seal (KES 379.27). The maximum difference was KES 83.67 ($0.837), the difference between U. seed company and T. packet seal. Unlikely this is because of trust issues (Table 4.5). U. seed company was the only maize seed packet in which the average price was the market price. The local maize seed is valued as the lowest and it is three to five times less compared to improved maize seed varieties. All the maize seed packets had a minimum WTP of KES 0 ($0). For the tampered packets it was 15% tampered date, 26% tampered scratch label, and 25% tampered packet seal. The maximum WTP varied, U. seed company, T. date, T. scratch label, and T. packet seal had a value of KES 899 ($ 8.99) the maximum WTP, KES 882 ($8.82) for U. multiple sources and KES 500 ($5) for the traditional variety. The traditional variety is not considered in the analysis as it is a different product from improved maize seed varieties.

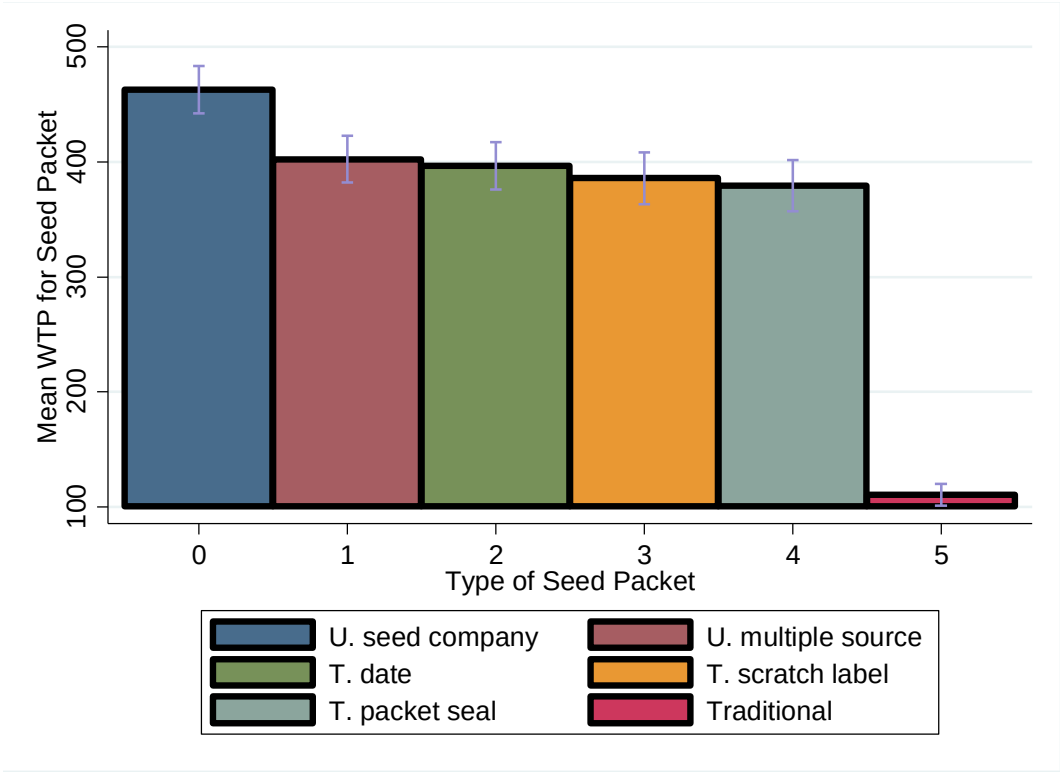


Figure 4.7: Mean WTP for Various Seed Packets

A paired t-test of the difference of means between the tampered packets is only significant for T. date and T. packet seal (p-value <0.05; Table 4.7). Participants did not distinguish between tampered date and scratch label and discounted the most tampered packet seal. Comparison of different levels of tampering with the source of maize seed shows that farmers attach a premium (KES 60) for a seed packet sourced from the seed company compared to agro-vet. A paired t-test of the difference of means between U. multiple sources with tampered seed packets (Table 4.7) shows that T. packet seal (p value<0.05) and T. scratch label (p value<0.10), the means are significantly different from U. multiple sources and insignificant for U. multiple sources and T. date. A similar test

with U. seed company with other packets shows that the means are highly significantly different (p-value<0.01) from the tampered packets. They attach a higher premium to the seed packets purchased directly from the seed company.

Table 4.7: The Mean Difference of WTP for the Various Seed Packets (N=262)

Maize seed packet	Mean bid	Std. deviation	Mean difference (2) or (3) and (1)	Std. error	Significance
(1) T. packet seal	379.27	0.00			
(2) T. scratch label	385.87	184.90	6.60	7.08	
(3) T. date	396.91	169.30	17.64	7.56	**
(1) T. scratch label	385.87	184.90			
(2) T. date	396.91	169.30	11.04	7.98	
(1) T. packet seal	379.27	181.85			
(2) U. multiple sources	402.44	166.16	23.16	9.21	**
(3) U. seed company	462.94	181.85	83.66	11.47	***
(1) T. scratch label	385.87	184.92			
(2) U. multiple sources	402.44	166.16	16.57	8.78	*
(3) U. seed company	462.94	181.85	77.07	11.47	***
(1) T. date	396.91	169.29			
(2) U. multiple sources	402.44	166.16	5.53	8.99	
(3) U. seed company	462.94	181.85	66.03	10.32	***

*Significance codes: *** p<0.01, ** p<0.05, * p<0.1

Examining the effect of training on best seed purchasing practices on the WTP for seed packets. Participants were grouped into two, training group (52%) that received training on the best seed purchasing practices and a control group (48%) that did not receive training. There were more participants in the training group that had not undergone training (68.4%) than the control group (49.1%) before the study. Farmers in control group were

willing to pay a higher premium for the tampered packet and lower for an untampered packet for the improved varieties compared to training group who are willing to pay more for the untampered seed packets and less for the tampered packet (Figure 4.8).

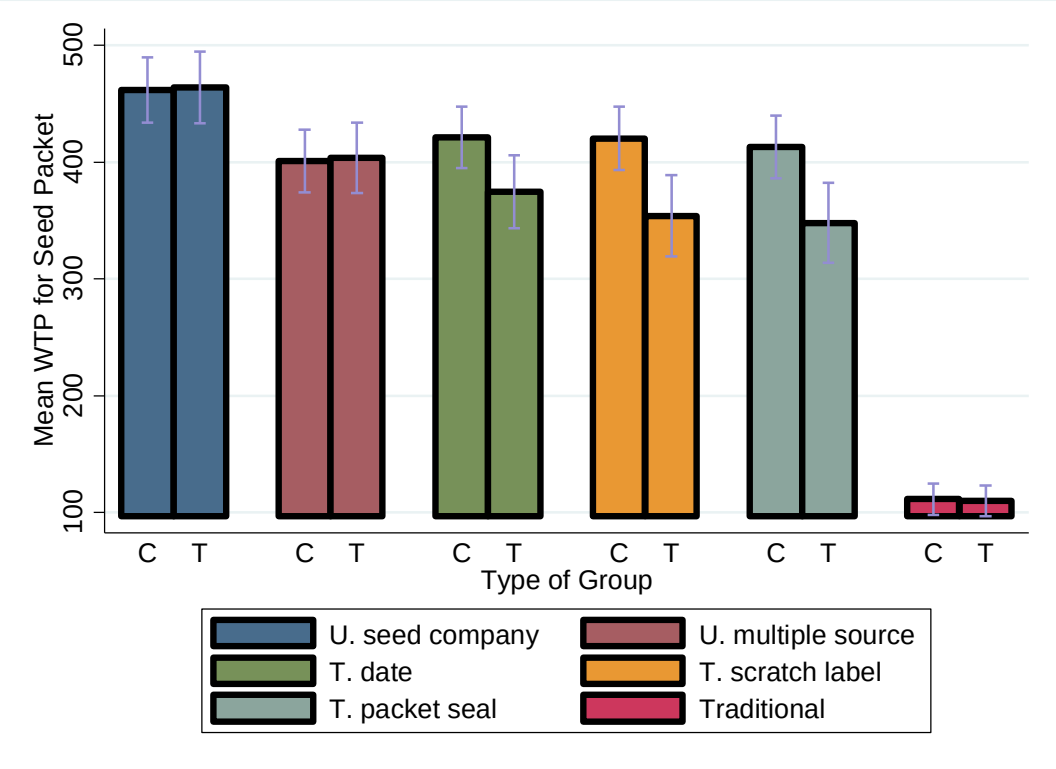


Figure 4.8: Mean WTP for Training and Control Groups for Various Seed Packets
*C is the control group and T the training group.

Further analysis with a t-test shows that only three of the six seed packets, the means are significantly different at 5% level between the groups. These are the packets that are tampered with, T. date (p-value < 0.05), T. scratch label (p-value < 0.01) and T. packet seal (p-value < 0.01). Participants discounted T. packet seal the most, followed by T. scratch label and lastly T. date for both the groups. The control group did not distinguish between

the type of tampering of seed packets. No significant difference is observed between the different tampered packets. I observe a significant difference for the training group between T. date and T. packet seal (p value<0.05) with no significant difference between T. scratch label and T. date and T. scratch label and T. packet seal. Provision of training enables farmers to attach a value to the form of fraudulent activity. They discounted most tampering inform of the scratch label and packet seal and least to date.

Training group valued intact packets more as opposed to the tampered improved varieties packets (Table 4.8). The control group the valuation is higher only for U. seed company and U. multiple sources is the lowest of all the improved maize packets. The difference of means for each group between the seed packets is disclosed in Table 4.8 with the level of significance. Comparison of means (paired t-test) in the control group between U. multiple sources and the tampered packets, shows that it is significantly lower than T. date and T. scratch label (p value<0.05). This may be due to the inability to distinguish intact packets from tampered packets. The only way they could distinguish seed packets was the source of seed and attached a premium to seed company packet (U. seed company) and it was significantly different from the tampered packets. However, the training group attaches a higher premium for both U. multiple sources and U.seed company. It was higher for U. seed company than U. multiple sources compared to other tampered packets and it was significantly different. They were able to distinguish the tampered packets from the intact packets. They discounted the most tampered seal, followed by the tampered label and lastly tampered date.

Table 4.8: The Mean Difference of WTP for Control and Training Group (N=262)

Maize seed packet	Control				Training			
	Mean bid	Mean difference (2) or (3) and (1)	Std. error	Significance	Mean	Mean difference (2) or (3) and (1)	Std. error	Significance
(1) T. packet seal	412.92				348.10			
(2) T. scratch label	420.36	7.44	7.36		353.92	5.82	11.83	
(3) T. date	421.11	8.19	8.87		374.49	26.39	12.00	**
(1) T. scratch label	420.36				353.92			
(2) T. date	421.11	0.75	9.11		374.49	20.57	12.83	
(1) T. packet seal	412.92				348.10			
(2) U. multiple sources	401.01	-11.91	8.33		403.76	55.66	15.49	***
(3) U. seed company	461.79	48.87	11.64	***	464.00	115.90	18.91	***
(1) T. scratch label	420.36				353.92			
(2) U. multiple sources	401.01	-19.35	9.69	**	403.76	49.85	13.77	***
(3) U. seed company	461.79	41.44	12.70	**	464.00	110.08	18.30	***
(1) T. date	421.11				374.49			
(2) U. multiple sources	401.01	-20.10	9.42	**	403.76	29.27	14.70	**
(3) U. seed company	461.79	40.68	11.22	***	464.00	89.51	16.73	***

*Significance codes: *** p<0.01, ** p<0.05, * p<0.1

4.5 Tobit Model

A tobit model was used to analyze the results more formally (Table 4.11; Model 5). A hurdle model was inappropriate for this study, because none of the participants had zero bids for all of the seed packets. The majority (89%) of the zero bids of improved maize seed varieties (excluding traditional) were the tampered packets and 94% of them came from those that received training. The shift to zero bids was as a result of training on best seed purchasing practices. Table 4.9 and Table 4.10 shows the summary statistics for socio-demographic, economic, and cognitive variables used in the model. Model 1 and Model 2 are basic models with only the treatments, Model 3 and Model 4 introduces training, seed, and interactions of seed and training, and Model 5 and Model 6 are full models that control for sociodemographic, economic, village, and cognitive characteristics. The standard errors were clustered at the individual level based on household identification numbers. The Housman test between the random effect model and fixed effect model in the GLM regression for Model 1, the p-value is 1 and hence the random effect model is the most preferred method. The lower limit is KES 0 and the higher limit is KES 899. The dummy variables are the baselines: multiple source untampered packet (treatment), no video (training), and Duma 43 (seed), low level of concern (concern), and other seed packets except U. seed company (company_seed). The coefficients are the estimated differences from the baseline.

Table 4.9: Descriptive Statistics of Sociodemographic and Economic Variables*

		Control Group		Training Group		Overall Group		
Variable	Description	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Units
Training	1 if the respondent received best seed purchasing practices training	-	-	-	-	51.91	0.50	Percent
Variety	1 if selected seed is DK8031; 0 if Duma 43	21.00	0.41	17.00	0.38	18.7	0.39	Percent
Gender	1 if the respondent is female; 0 if male	61.00	0.50	62.00	0.49	61.45	0.49	Percent
Head	1 if the respondent is the household head; 0 otherwise	71.00	0.46	74.00	0.44	72.14	0.45	Percent
Education	Number of completed years in school	7.83	3.03	7.03	3.39	7.42	3.95	Yeas
Acreage	Planted maize acres in the main season	1.70	2.56	1.37	1.42	1.52	2.05	Acres
Wang'nenoWTP	Mean WTP for Wang'neno village	270.60	154.98	349.37	234.38	316.93	171.61	KES
NyaberaWTP	Mean WTP for Nyabera village	356.90	187.23	283.45	189.26	318.81	187.44	KES
NyokwanyWTP	Mean WTP for Nyokwany village	360.38	206.91	305.64	185.30	340.05	200.47	KES
NyariaroWTP	Mean WTP for Nyariaro village	378.05	161.91	329.86	239.47	345.92	217.49	KES
OgandeWTP	Mean WTP for Ogande village	390.10	215.77	345.52	162.88	363.35	191.27	KES
MatangweWTP	Mean WTP for Matangwe village	384.52	170.23	334.57	170.49	365.18	208.64	KES
UdimbaWTP	Mean WTP for Udimba village	396.53	144.40	353.41	207.96	369.58	194.41	KES
NyawitaWTP	Mean WTP for Nyawita	417.17	178.57	431.29	216.86	422.81	186.64	KES

*N=262

Table 4.10: Descriptive Statistics of Cognitive Variables (N=251)

Variable	Description	Mean	Std. Dev
On a 5-point scale, how much do you trust the following sources of seed to provide you with high-quality genuine seed? From 1 =not at all to 5=extremely reliable			
Company	Seed company	4.72	0.60
Agro-vet	Stockists or agro-vet	3.96	0.89
Trust_difference	Mean difference in the level of trust between seed company & agro-vet/stockists	0.75	1.01
Company_seed	1 if the packet was purchased directly from the seed company; 0 otherwise	0.14	0.35
On a scale of 1-5, how concerned are you about the following issues affecting maize farming? 1=not at all concerned to 5=extremely concerned			
Concern	1 if concern of counterfeit seed is 4 or 5 (high level); 0 otherwise	2.65	1.45

*Some participants had no opinion on the variables and were excluded in the analysis.

The results are robust across the models. The coefficients estimate of Tobit and GLM random effects model vary in magnitude. The statistical significance level is observed in the same places with only one having varying levels of significance, the interaction of multiple sources tampered date and training (Model 3 and Model 4). Nonetheless, it is consistent when I control for socio-demographic, economic, village, and cognitive variables (Model 5 and Model 6). Post hoc statistical power test was performed with a Gpower 3.1 software. The effective size ((mean group 1- mean group 2)/ standard error) used in the calculation of statistical power was small (0.15) based on Cohen's (1988) measure at a p-value of 0.05 and a sample size of 126 for those that did not receive training for best seed purchasing practices and 136 for training group without considering the different seed packet treatments. The study achieved a power of 0.33.

We examine the effects of tampering in WTP for maize seed packets. Participants that bid on DK 8031 had a higher WTP compared to those that selected Duma 43. However, no significant difference was found between DK 8031 and Duma 43. Seed packet U. multiple sources was an untampered multiple source packet, and I compared the WTP for this packet with the WTP for other tampered packets and U. seed company. Holding other variables constant, participants were willing to pay less for U. multiple sources; KES 451.58 compared to all the seed packets except for local seed (66% less). The highest premium was attached to U. seed company followed by T. date, T. scratch label, and lastly T. packet seal. It was 14% more for U. seed company (KES 61.25), 4% more for T. date (KES 20.13) and T. scratch label (KES 17.58), and 2% more for T. packet seal (KES 9.24). The results are different from the comparison of means in Table 4.7 but similar to Model 1. None of the tampered packets the means is different from U. multiple sources. The significant difference is only observed for U. seed company and Traditional (p value<0.01). We, therefore, reject hypotheses 1, participants are willing to pay more for a seed company seed packet only. They did not attach a value to any type of tampering and group them under the same umbrella, seeds from the agro-vet. The results enable us to conclude that farmers attach a premium for a seed packet sourced from the seed company.

Looking at the interaction of seed packets and training, I observe significant results. Controlling for other variables, provision of training changes the perception of farmers on tampered packets. The coefficient for interaction was negative for tampered packets and positive for U. seed company. Participants in training group discounted tampered packets, KES 57.32 less for T. date, much lower for T. scratch label (KES 76.61), and lowest for T.

packet seal (KES 76.79), with no much difference with U. seed company (KES 4.48) compared to control group. They were able to differentiate the seed packets from multiple sources and discount all tampered packets from U. multiple sources. The results are similar to the t-test. A significant difference of means is observed for tampered packets (T. date, T. scratch label, and T. packet seal) between the two groups (p value<0.01). For U. seed company packets, the means are not different from each other. I thus reject hypotheses 2. Based on the results we can conclude that provision of information about best seed purchasing practices will change farmers' perceptions when buying maize seed and have a negative influence on their WTP for maize seed that has been tampered with.

Furthermore, I examine the effect of cognitive variables in WTP: trust_difference and concern (Table 4.10). Holding other variables constant, participants were willing to pay a premium of 1% (KES 6) for U. seed company for every increase in trust level differences and less than 1% (KES 2) for other packets. I cannot reject hypotheses 3. Finally, I examine the effects of high concern of counterfeits in WTP for maize seed packets. Holding other variables constant, participants who were highly worried about counterfeit seeds discounted seed packets by 2% (KES 9) compared to other participants. It did not have a significant effect on WTP and therefore I reject hypotheses 4. Based on the results I can conclude that difference in trust levels on the sources of the seed and the level of concern of counterfeit seeds does not play a role in determining participants WTP for maize seed packets.

Table 4.11: Random Effects Tobit and General Linear Regression Model (GLM).

	Model 1 (TOBIT) WTP	Model 2 (GLM) WTP	Model 3 (TOBIT) WTP	Model 4 (GLM) WTP	Model 5 (TOBIT) WTP	Model 6 (GLM) WTP
T. date	-6.26	-5.53	20.88	20.10	20.13	19.30
	(10.18)	(9.78)	(14.49)	(13.96)	(14.72)	(14.18)
T. scratch label	-18.76*	-16.57*	19.37	19.35	17.58	17.56
	(10.19)	(9.78)	(14.49)	(13.96)	(14.71)	(14.17)
T. packet seal	-25.12**	-23.16**	11.92	11.91	9.24	9.17
	(10.18)	(9.78)	(14.49)	(13.96)	(14.76)	(14.21)
U. seed company	61.75***	60.50***	61.63***	60.79***	61.25***	60.35***
	(10.17)	(9.78)	(14.49)	(13.96)	(14.73)	(14.18)
Traditional	-298.71***	-291.77***	-293.12***	-289.59***	-299.74***	-296.09***
	(10.25)	(9.78)	(14.54)	(13.96)	(14.80)	(14.20)
Training			8.19	8.90	4.89	5.53
			(20.56)	(20.17)	(20.85)	(20.52)
T. date*training			-52.41***	-49.38**	-57.32***	-54.15***
			(20.14)	(19.38)	(20.48)	(19.69)
T. scratch label *training			-73.76***	-69.19***	-76.61***	-71.86***
			(20.16)	(19.38)	(20.51)	(19.70)
T. packet seal*training			-71.64***	-67.57***	-76.79***	-72.23***
			(20.16)	(19.38)	(20.49)	(19.69)
U. seed company*training			0.13	-0.55	4.48	3.77
			(20.12)	(19.38)	(20.45)	(19.69)
Traditional *training			-10.51	-4.21	-6.58	0.03
			(20.28)	(19.38)	(20.62)	(19.69)

DK 8031			16.79	15.16	14.77	12.98
			(21.19)	(21.03)	(21.10)	(21.06)
High level of concern					-9.43	-8.78
					(17.02)	(16.98)
Trust_difference* Company_seed (0)					1.78	2.18
					(8.07)	(8.04)
Trust_difference* Company_seed (1)					5.86	6.55
					(10.00)	(9.81)
Constant	401.46***	402.44***	426.78***	426.22***	451.58***	450.23***
	(10.40)	(10.03)	(46.29)	(45.89)	(48.44)	(48.28)
Socio-demographic, economic, and village controls			X	X	X	X
Cognitive controls					X	X
Wald chi2	1516.09	1608.58	1608.23	1696.70	1601.52	1689.77
χ2 p-value	0.00	0.00	0.00	0.00	0.00	0.00
Overall R2		0.33		0.37		0.39
log likelihood	-9588.85		-9560.32		-9137.32	
Number of households	262	262	262	262	251	251
Total observations	1,572	1,572	1,572	1,572	1,506	1,506
Left censored observation	72		72		72	
Right censored observation	5		5		4	

Notes: ***, **, * represent significance at the 1%, 5% and 10% levels, respectively. Estimates include subject random effects. Sociodemographic, economic, village and cognitive controls are summarized in Table 4.9 and 4.10. Models 1, 3, and 5 are Tobit random effects models. Models 2, 4, and 6 are GLM random effects models.

Chapter 5

DISCUSSION AND CONCLUSION

Seed fraud is still a major issue affecting farmers and has received a lot of attention from the media and other sources. Understanding how farmers react to tampered seed packets can capture the richness of actual seed selection process and valuation decision in the presence of fake seeds in the market. Quality assurance on a products makes farmers attach a premium. They were willing to pay KES 61 more for an untampered seed company packet than from an agro-vet. Similar findings were found by Bold et al. (2017) in Uganda were farmers were willing to pay a premium for a bag of fertilizer in which the quality was assured. This is because guarantees by seller reduce the uncertainty of quality (Akerlof 1978; Li 1995).

I found out that tampering of maize seeds was a major issue, most farmers would purchase a tampered maize seed packets only when it was discounted: Tampered date KES 395, tampered scratch label KES 383, tampered seal KES 376, and untampered packet KES 402. They attached a higher value to a broken packet seal than a scratched label and discount it from the untampered packet. The tampered date did not appear to raise a red flag. They did not discount the tampered date packet as they could not understand the sampling date on the packet of seed based on the informal discussion. Some participants were not willing to purchase the tampered packets. Similar results were observed in a study by Ashour et al. 2017 where 31% of the respondents stopped buying herbicides because

they were not sure of the quality. However, when I hold other factors affecting WTP constant, the average WTP for all the tampered seed packets from multiple sources were not statistically different from untampered multiple source packet, except for untampered seed company packet.

Kamau and Baumgartner (2013) and Karingu and Ngugi (2013) advocated that farmers should verify the packet to avoid purchasing fake products. Novel features e.g. scratch label has been introduced on a packet of seed to protect farmers from fake seeds. Only a few farmers know of its existence. Our results showed farmer training on best seed purchasing practices led to a significant reduction in WTP for tampered packets but not WTP for untampered packets. I speculate the reason is that training enabled farmers to identify the different types of tampering on a seed packet. They attached a higher discount for a tampered packet seal followed by a tampered label and lastly a tampered date. For the seed company packet, farmers were willing to pay more than twice the premium for untampered versus tampered packets. Those that did not receive training, no significant difference was found between untampered multiple source seed packet and tampered packets. They did not check features in the maize seed packet based on the informal discussion.

The difference in trust between the seed company and agro-vet had no effect on the WTP. This was unexpected, the reason could be farmers did not relate quality to trust level. Notably, those that had the highest positive differences the average WTP was the lowest for the seed company packet. Seed company had no reported cases of fake seeds by respondent, which was, therefore, the most trusted source. Reported cases of fraud were

very high from the small traders and agro-vets. This was also observed in a study by Deloitte (2014) in Uganda where 80% of the counterfeiting in herbicides was done by agro-dealers, informal suppliers, and distributors.

The high concern of the presence of fake seeds had no effect on WTP. The reason could be that farmers attach a small weight to the effects of planting fake seeds. Only 15% of the farmers said that they would report to the relevant authorities when they realized they had purchased fake seeds. In a study by Mabaya and Mburu (2016) in Kenya, seed companies were very concerned about fake seeds but only six cases yearly have been reported since 2013. The checking of valid date was the most popular best seed purchasing practices that were used to verify the quality of maize seed. This was also seen in a study by Shao and Edward (2014) in Tanzania where 19% of the farmers based quality on the date.

This study focused on tampering on maize seed packets sourced from multiple source agro-vets and not the seed companies. Further research will be needed to know if the different types of tampering will have an effect on the seed company packet. In addition, in the training, I did not incorporate any information on yield loss as a result of planting fake seeds. Most farmers discounted tampered maize seed packets. However, it is not clear if they purchased the tampered packets because they attach less weight to the type of tampering or because they do not know the consequences of the possibility of planting fake seeds on yield. Furthermore, a better understanding of the perceived difference between sampling date and valid date on a seed packet, the difference between low-quality seed and counterfeit seeds and if a farmer will purchase a maize seed packet with a positive

probability of being fake will provide more insight on farmer seed decision-making process.

Quality assurance of maize seeds eliminates the lemon problem to farmers and it is an appropriate policy intervention. This is because farmers' preferences for maize seeds are influenced by learning and the source of seed and not trust nor fear of fake maize seeds in the market. This can be achieved by enforcing strict policies and very high penalties along the seed distribution chains. The opportunity cost of selling fake products will be high compared to the gains deterring counterfeiting. The seed company has the incentive to sell it seeds directly to farmers or exclusively through established agro-vets. A tracking system and independent testing of seeds can easily be implemented with a record of suppliers. It will ensure high-quality genuine seeds to farmers and maintain the seed company reputation.

Substantial effort will be needed to educate farmers on how to identify high-quality genuine products. Frequent training on best seed purchasing practices should be introduced especially when new features are introduced on a seed packet, as more information is better. The best means through which farmers can get information is the radio. Packet features should be incorporated into the training as it varies among maize seeds e.g. plastic and paper packet. This will ensure farmers fully realize the benefit of training and the information cut across all the varieties. This can be achieved by seed companies increasing the amount of expenditure on education and awareness of farmers by organizing promotional trips to rural areas. The promotional trips should not only include the types of the products but also the special features on a packet of seed and the trusted seed

distributors in the area. Seed companies will be assured that no matter the advancement of fraudulent activities on a packet of seed farmers are equipped with skills and knowledge on how to identify genuine products.

More information is needed on the seed packet to help farmers make informed purchasing decisions. Nowhere in the packet did it explain the purpose of the scratch label nor the cost of sending the text. The scratch label should incorporate this as most rural household tend to be poor and may be reluctant to try it out due to cost e.g. scratch and text for free to 1393 to verify the authenticity of the seed. Farmers are advised to check for expiry dates when purchasing seeds but only sampling date is on the packet of maize seeds. The sampling date assures farmers the seeds have met the minimum standards and within a year, it is still valid unless the validity certificate on the seed has been withdrawn by KEPHIS. This should also be stated on the packet. Alternatively, seed companies can use “best before” or “sell by” dates instead of the sampling date e.g. packed for 2018 sell by December 2018 for maize seeds. Food and other items have warning labels on the packet for quality control e.g. do not accept if seal is broken. The same can be applied to a seed packet it can state, do not accept if packet seal is broken or the date is altered, or when the label is scratched.

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Appendix A

QUESTIONNAIRE

The questionnaire was administered on a tablet and read out loud in the local language by an enumerator. A written, English version of the questionnaire is provided below.

Please Fill the Following Demographic Questions (Check One)

1. What is your gender?
   - 1-Female
   - 2-Male
2. Relationship to household head?
   - Head
   - Spouse
   - Child
   - Parent
   - Sibling
   - Grandchild
   - Son/daughter in law
   - Other specify
3. What is the highest level of education that you have completed? (Number of years)?

   _____

Land Details and Maize Productivity

1. Which season did you plant maize? (*Check all that applies)*

- Main Season
- Short Season
- None

Main season (April 2017-Aug 2017)

1. How many acres of OWNED land were cultivated with maize in the main season of 2017?

   _____

2. How many acres of RENTED land were cultivated with maize in the main season of 2017?

   _____

3. What was the main maize seed variety planted in the main season of 2017? **Seed variety Codes**

   _____

4. Where did you source your maize seed in the Main Season? **Source Code**

   _____

Short Season (September2017- December 2017)

5. How many acres of OWNED land were cultivated with maize in the short season of 2017?

   _____

6. How many acres of RENTED land were cultivated with maize in the short season of 2017?

   _____

7. What was the main maize seed variety planted in the short season of 2017? **Seed variety Codes**

   _____

8. Where did you source your maize seed in the short season? **Source Code**

   _____

Source Code

1-Small trader 2-Stockist/Agent/Agro vet 3-Kenya Farmers Association (KFA) 4-Cooperative 5-Farmer/Neighbor 6-General Market 7-Government of Kenya 8-Farmer group 9-NGO/Community based organization (CBO) 10-Large company 11-Other specify …….

Seed variety Codes

1	Don't know	13	DK 8031	25	Kakamega Synthetic	37	KS 516	49	KS 622	61	KSTP 94	73	Pan 691	85	Sadvil B	97	WS 301	109	WS 509
2	Indig/Traditional	14	DK 8051	26	KAMANO	38	KS 520	50	KS 623	62	Makueni	74	PAN 691	86	Sadvil Composite			110	WS 699
3	CG 4141	15	DK 8053	27	Katumani	39	KS 611	51	KS 624	63	Maseno DC	75	Pan 99	87	SC 506	99	WS 402	111	WS 904
4	CG 5051	16	DK 8071	28	KH 600-11D	40	KS 612	52	KS 625	64	Monsanto	76	Pan67	88	SC 513	100	WS 403	112	WS 905
5	CG 5252	17	DLC	29	KH500-21A	41	KS 613	53	KS 626	65	MRI 624	77	PANNAR	89	SCDUMA43	101	WS 404	113	WS 909
6	Coast Composite	18	DUMA 41	30	Kinyanya	42	KS 614	54	KS 627	66	PAN 33	78	PH 1033	90	Simba	102	WS 500	114	Other, specify
7	DH 02	19	DUMA 43	31	KS 1920	43	KS 615	55	KS 628	67	PAN 4M-19	79	PH1	91	Striga-resistant/WS 303/ua kayongo	103	WS 501		
8	DH1	20	Faida Seed 650	32	KS 511	44	KS 616	56	KS 629	68	Pan 5195	80	PH2	92	WS 103	104	WS 502		
		21	H 515	33	KS 512	45	KS 621	57	KS 636	69	PAN 52	81	PH4	93	WS 105	105	WS 503		
10	DH3	22	H 516	34	KS 513	46	KS 6210	58	KS 9201	70	Pan 5243	82	Pioneer	94	Punda milia	106	WS 504		
11	DH4	23	H 613	35	KS 514	47	KS 6212	59	KS 9401	71	Pan 5355	83	Rwanda	95	WS 202	107	WS 505		
12	DK 3081	24	H 624	36	KS 515	48	KS 6213			72	Pan 612	84	Sadvil A	96	WS 205	108	WS 507		

Credit

1. Are you or any member of your household have access to credit in the last 12 months?

   Not household consumable

   - ☐ Yes
   - ☐ No

Source of Income

1. What is your household's main source of income?

   - ☐ Cropping Activities
   - ☐ Sale of livestock and livestock products
   - ☐ Formal employment
   - ☐ Informal activity
   - ☐ Other, Please specify

Awareness

1. Before the study, were you aware that, on some seed packets, there is a label that you can scratch to obtain a 12-digit pin number that you can send via SMS to verify the authenticity of the seed?

   - ☐ Yes
   - ☐ No

2. If yes, how many times have you used this services?

   - ☐ Never
   - ☐ Once
   - ☐ A few times
   - ☐ Every time I buy a packet of seed

3. How often do you do the following?

	Never	Rarely	Sometimes	Often	Always
A. Check for a registered seed merchant license from any agro-vet before purchasing seeds?	☐	☐	☐	☐	☐
B. ad instructions on the packet of the seed before planting?	☐	☐	☐	☐	☐

4. Before the study, what do you look for or do to ensure that the maize seeds you purchase are genuine and of high quality? Check all that apply:

- ☐ Valid date
- ☐ Unscratched label
- ☐ Intact packet seal
- ☐ Normal price range
- ☐ Type of seed merchant e.g. agro-vet, seed agent
- ☐ Packet design
- ☐ Dye of seeds (genuine dye do not stick to hands/cloth)
- ☐ KEPHIS logo
- ☐ Germination rate
- ☐ Dye of the seed's packet

5. On a 5-point scale, how much do you trust the following sources of seed to provide you with high-quality genuine seed?

- ☐ small trader _____
- ☐ stockists/agent/agro-vet _____
- ☐ large company _____
- ☐ Non-government organization (NGO.) _____
- ☐ Community based organization (CBO.) _____
- ☐ Kenya Farmers Association

- Purchase early in the season
- Buying specific variety
- Other specify _____

(KFA.) _____

- Cooperative _____
- Farmer /Neighbor _____
- General market _____
- Government of Kenya (GoK.) —
- Farmer group _____
- Other, specify_____

6. Which packaging material for a maize seed packet do you prefer?
   - Plastic
   - Paper
7. Why do you prefer the selected packaging material? (select all that apply)
   - The packet is not easily damaged by pests
   - Water resistant
   - The packet is not easily damaged by factors other than pests
   - Difficult to tamper with the packaging
   - Attractive
   - Other specify_____

Seed Fraud

1. On a scale from 1-5, how concerned are you about the following issues affecting maize farming?

	Not at all (1)	Slightly (2)	Moderately (3)	Very (4)	Extremely (5)	Not Applicable (0)
A. Fall armyworm	☐	☐	☐	☐	☐	☐
B. Maize Lethal necrosis	☐	☐	☐	☐	☐	☐
C. Fraudulent and counterfeit seeds	☐	☐	☐	☐	☐	☐
D. Too much rainfall	☐	☐	☐	☐	☐	☐
E. Too little rainfall	☐	☐	☐	☐	☐	☐
F. Severe weather (storms, winds)	☐	☐	☐	☐	☐	☐
G. Low quality seeds	☐	☐	☐	☐	☐	☐

2. Before the study, have you received information or training about how to ensure the maize seeds you purchase is genuine and of high quality from any of the following groups (tick all that apply)?

- ☐ No, l have not received any training (before today)
- ☐ Government Agent

- NGO's
- Farmers' Organizations
- Community-Based Organization (CBO)
- Faith Based Organization (FBO)
- Input Dealer
- Research Organization
- Other farmers, relatives, and friends
- Radio
- Local leaders and Barraza
- Farmers training Centre/Agriculture training center (ATC)
- Other specify _____

3. Have you or heard of anyone who has purchased fraudulent maize seed in the past?

- No
- Yes-I have purchased fraudulent seed
- Yes- I have only heard of others purchasing fraudulent maize seed

4. (only if you had purchased fraudulent seed) When did you buy the seed that you think was fraudulent?

- More than 30 days before the beginning of the planting season
- 1 to 30 days prior to planting season
- After the start of the planting season

5. Why did you suspect the seed was fraudulent (tick all that apply)?

- ☐ Low yield
- ☐ Different packaging design
- ☐ Tampered packet seal
- ☐ Tampered date
- ☐ Tampered certification scratch code label
- ☐ Quality of dye on the seed
- ☐ Lack of KEPHIS logo
- ☐ Quality of the dye on the seed packet
- ☐ Low germination rates
- ☐ Expired date
- ☐ Other specify……..

7. What would you do if you thought that you had purchased counterfeit seeds? (tick all that apply)
    - ☐ Report to the Seed company
    - ☐ Report to KEPHIS

6. Where was the seed purchased? (tick all that apply)
    - ☐ Small trader
    - ☐ Stockists/agent/agro-vet
    - ☐ Large company
    - ☐ NGO
    - ☐ CBO
    - ☐ KFA
    - ☐ Cooperative
    - ☐ Farmer /Neighbor
    - ☐ General market
    - ☐ GoK
    - ☐ Farmer group
    - ☐ Other, specify……

- Report to local authorities e.g. chief
- Report to police
- Plant local variety only
- Change the maize seed variety
- Reduce the quantity of improved variety purchased
- Change the place of purchase
- Get insurance coverage
- Other specify _____

Contact Details: Phone number that you can be reached? _____

Appendix B

EXPERIMENTAL INSTRUCTIONS

Welcome! Thank you for coming today.

You have agreed to participate in a research study about individual decision-making. The purpose of our study is to better understand how farmers make decisions about purchasing maize seed.

Various research foundations have provided funds for this research.

This research session has two parts. Each participant will receive KES 10 for Part 1 and KES 900 for Part 2.

In each part of this session, you will have the opportunity to buy different types of products. Your decisions will be real, meaning that you will actually be able to buy these items. We will clearly explain the rules before we begin each part of the session.

During this session, we ask that you do not communicate with other participants. Please refrain from verbally reacting to events that occur during the session. This is very important.

PART 1

You will be paid KES 10 for participating in Part 1 of this research session.

In this part, you have an opportunity to buy candy. There are five steps that you will follow:

1. You will be shown three different candies labeled (A), (B), and (C), and you will have an opportunity to inspect them. Each person has the same three types of candy at their table.
2. You will be asked to state the maximum amount of money that you are willing to pay for each candy between 0 KES and 9 KES.

3. Someone in your group will randomly select an envelope from our basket and someone else will open it to determine which piece of candy has been selected for potential purchase. This is the only one of the candies that you will have the opportunity to buy.
4. A random price will be generated for the selected candy by rolling a green dice. The green dice is ten-sided and includes numbers 0-9. The price will equal whatever number is rolled with the dice. For example, if the dice lands on 5, the price will equal KES 5.
    - Each of the values has an equal probability of being selected.
    - Your decision does not have any effect on the random price
5. Purchase decisions will be determined - the actual purchase will depend on a randomly drawn price.
    - If the random price is lower than or equal to the amount that you said you would pay for the candy, then you will buy the candy and pay the randomly drawn price.
    - If the random price is higher than the amount that you said you would pay for the candy, then you will not buy the candy.

Example

Imagine that you gave someone money and asked them to go into a shop to buy you a piece of candy with the money that you gave them. If you gave that person enough money, the person would buy the candy and return the left-over money. If you did not give that person enough money, the person would not buy the candy and would instead give you all of your money back. In this example, the money that you give to the person is the stated amount of money that you are willing to pay, and the price at the shop is the random price.

Note that it is in your best interest to tell us how much you are truly willing to pay for each candy.

Example

If a piece of candy is worth KES 7 to you, then it is in your best interest to say that the piece of candy is worth KES 7. We will explain why.

- If you stated that you are willing to pay KES 5, then you are missing out on the opportunity to buy the candy for KES 6 or KES 7. For example, if the random price was KES 6, you would not be able to buy the candy because you said that you were only willing to pay KES 5. You would have been better off to state that you were willing to pay KES 7. That way, you could buy the candy if the random price was KES 7 or lower.
- If you stated that you were willing to pay KES 9, then you might have to pay more money for the candy than you want to pay. If the random price is KES 8 or KES 9, you would buy the candy if you stated that you were willing to pay up to KES 9, but if you only think the candy is worth KES 7, you would be better off stating that you are only willing to pay KES

WORKSHEET FOR PART 1: Village _____ ID # _____

	Maximum amount you are willing to pay (KES)
What is the maximum amount that you are willing to pay for **Candy A?**	_____
What is the maximum amount that you are willing to pay for **Candy B?**	_____
What is the maximum amount that you are willing to pay for **Candy C?**	_____

Randomly selected candy (From Envelope circle one): A B C

Randomly selected price (Determined with green dice): KES _____

Was the candy purchased? (circle one). YES NO

Note: The selected candy is purchased if the random price is less than or equal to the price that the participant was willing to pay for the selected seed.

Payment for this part: _____

Note: The payment equals [10 KES – random price] if the candy is purchased and [10 KES] if the candy is not purchased.

PART 2

You will be paid KES 900 for participating in Part 2 of this research session.

In this part, you have an opportunity to buy maize seed. There are five steps that you will follow:

1. You will choose whether you prefer Duma 43 or DK 8031. You will then be shown five packets of the type of seed that you choose and one traditional variety. You may inspect each packet.
    - Packets A, B, C, and D were purchased from multiple different retail locations including seed agents, stockists, local markets and shops near your village.
    - Packet E was purchased directly from the seed company.
    - Packet F is the traditional variety purchased from the traditional market.
2. You will be asked to state the maximum amount of money that you are willing to pay for each packet between 0 KES and 899 KES. Only one packet will be randomly selected for purchase at the end of this part.
3. Someone in your group will randomly select an envelope from our basket and someone else will open it to determine which packet has been selected for potential purchase. You will only have the opportunity to buy the packet with that number.
4. A random price will be generated for the selected packet using 3 dice. A 10-sided blue dice labeled 0-9 will be rolled to determine the first number in the price. The roll will only count if the dice lands on a number between 0 and 8. If the dice lands on 9, you will roll again to ensure that the 3-digit number is between 0 and 899. A 10-sided green dice labeled 0-9 will be rolled to determine the second digit of the price. A 10-sided red dice labeled 0-9 will be

rolled to determine the third digit of the price. Each of the values has an equal probability of being selected.

5. Purchase decisions will be determined - the actual purchase will depend on the random price.
    - If the random price is lower than or equal to the amount that you said you would pay for the packet of seed, then you will buy the seed and pay the random price.
    - If the random price is higher than the amount you said you would pay for the packet of seed, then you will not buy the seed.

Example

This part of the session works just like the part you just finished with the candies.

Imagine that you gave someone money and asked them to go into a shop to buy you a packet of seed with the money that you gave them. If you gave that person enough money, the person would buy the seed and return the left-over money. If you did not give that person enough money, the person would not buy the seed and would instead give you all of your money back. In this example, the money that you give to the person is the stated amount of money that you are willing to pay, and the price at the shop is the random price.

Note that it is in your best interest to tell us how much you are truly willing to pay for each packet of seed just like with the candy in the first part of the session.

WORKSHEET FOR PART 2: **Village _____** **ID # _____**

Preferred type of maize seed (this is the seed that will be used in the experiment):

DUMA 43 ☐ **DK8031** ☐

What is the maximum amount of money that you are willing to pay for each of the following packets of seed?

Remember that only one packet will be randomly selected for purchase, so it is in your best interest to tell us the true amount that you are willing to pay for each packet.

	Maximum amount you are willing to pay (KES)
What is the maximum amount that you are willing to pay for **Seed A?**	_____
What is the maximum amount that you are willing to pay for **Seed B?**	_____
What is the maximum amount that you are willing to pay for **Seed C?**	_____
What is the maximum amount that you are willing to pay for **Seed D?**	_____
What is the maximum amount that you are willing to pay for **Seed E?**	_____
What is the maximum amount that you are willing to pay for **Seed F?**	_____

Randomly selected seed (circle one): A B C D E F

Randomly selected price (blue dice, green dice, red dice): KES_____

Was the seed purchased? (circle one). YES NO

Note: The selected seed is purchased if the random price is less than or equal to the price that the participant was willing to pay for the selected seed.

Payment for this part: _____

Note: The payment equals [900 KES – random price] if the seed is purchased and [900 KES] if the seed is not purchased.

Remember you had the opportunity to choose either Duma 43 or DK8031. What are the top 3 reasons why you selected the maize seed?

1: ……. 2: …… 3: ……

Codes: 1-Price 2-Availability 3-Habit 4-Taste 5-High Yielding 6-Drought 7-Pest Resistant 8_striga resistant 9-Large cobs 10-grain size 11-Heavy grain 12-stores well 13-Other specify _____

Of the three selected, what is the main reason? ……

Appendix C

TRAINING INFORMATION

There are various organizations and institutions that offer regulatory services for certified seeds. Services include registration of seed growers, inspection of certified seed, and post-certification controls e.g. seed testing of seeds from stockiest, marketplaces and farmers to monitor quality. Seed certification helps to ensure that farmers receive authentic, high-quality seed.

Kenya Plant Health Inspectorate Service, or KEPHIS defines certified seed as "Certified seed (genuine) is the seed that has met the minimum national set quality standards after undergoing field inspection(s), laboratory tests and post control tests."

Seed lots are not labeled or sealed before receiving a test result certificate from the government official seed tester after meeting the minimum quality standards. Certified seed label contains: -

- Species and cultivar of seed
- The seed lot number used to trace the seed
- Date of sampling
- The weight of the packet, packet or container
- The approximate date of expiry or period of validity of the declaration

One should check for the following when purchasing seeds

1. Buy seeds early enough to ensure that you are purchasing high-quality, certified seed.
    - Purchasing seed from seed merchants who are licensed by Kenya Plant Health Inspectorate Service (KEPHIS).

- Before buying the seed, you should get the seed seller license ID and send the number via SMS to 5354 to verify if they have been registered.
- Seed packet should have an unscratched label with Kenya Plant Health Inspectorate Service (KEPHIS) logo imprinted in silver foil and lot number and it cannot be removed without damaging the sealed packet seal.
- To verify that the seed is authentic and certified, you scratch the label and send the twelve-digit number to 1393 via SMS. You should scratch this label and text in the code after you purchase the seed, but before you leave the point purchase.

2. Verifying the following attributes of the seed packet:
    1. KEPHIS Label: On the outside of the seed packet, you should see a scratch label with a KEPHIS logo, but the label should not be scratched off before you purchase the seed.
    2. Quality of the dye on the packet and the seed: The dyes should not stick to fingers and clothes.
    3. Quality of packet stitching: The packet should be sealed with a continuous stitch using the same thread.
    4. Date: to ensure It is not expired or tampered with. For maize seed it should not exceed 1 year from the date of sampling or packaging.
    5. The shape and design of the packet. It should not be narrow or wide compared to the ones you had previously purchased. You can verify by calling the seed company if you notice a change in packaging.

6. Buy seed packed in official company packet containing variety name and lot number. Do not purchase seeds from open containers.

- If seeds do not meet any of the stated requirements there is a possibility that the seed has been tampered with. You should not buy seeds if you expect that they have been tampered with and contact KEPHIS or law enforcement.
- You can contact the following KEPHIS numbers: 0722516221, 0723786779, 0733874274 or 0734874141 to report this incidence.

7. You should take the following steps to …

1. After planting, keep the packet and receipt as these may be required as evidence in case you suspect that the seed was low-quality or fraudulent.
2. Do not expose the seeds to extreme weather conditions because it could damage your seed. For example, exposure to heat, moisture, or light can damage your seed.

Appendix D

IRB EXEMPT LETTER

UNIVERSITY OF DELAWARE
RESEARCH OFFICE
210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE:	November 29, 2017
TO:	Leah Palm-Forster, PhD
FROM:	University of Delaware IRB
STUDY TITLE:	[1154319-1] Understanding Kenyan farmers' seed purchasing decisions
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	November 29, 2017
REVIEW CATEGORY:	Exemption category # *(2)*

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.

cc: