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Analysis of Determinants of Adoption and Extent of Seed Treatment Technologies of Home-Saved Wheat Seeds among Wheat Farmers in Kenya: A Double Hurdle Model Approach

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***ABSTRACT**: Seed quality is a necessity in all attempts at achieving the country's agricultural development; particularly productivity. This study aimed at examining the determinants of adoption and extent of seed treatment of Home-saved wheat-seed among farmers in Kenya. This study was anchored on adoption theory. The study employed use of survey research design from a sample of 101 wheat farmers in Uasin Gishu County. Double hurdle model was used to access determinants of uptake and the extent of adoption of seed treatment of Home-saved wheat seeds. The findings showed that majority of the farmers 91.1% were male while only 8.9% were female; most of the wheat farmers had primary level of education (50.5%) followed by secondary education(31.7%), college education (13.9%) and university education (4.0%). Some of the significant determinants of adoption decisions comprised of gender, education level, household size, access to extension services, land tenure and distance from home to the nearest seed treater. Significant determinants of the extent of adoption include total land size, availability of wheat seed treatment equipment, expected better wheat prices, access to credit and gross income from wheat production. The study recommended provision of more trainings, availing of treatment equipment, price incentives and diversification of income of wheat farmers.*
***KEYWORDS:** Determinants, Seed Care Treatment, Double Hurdle Model*

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I. INTRODUCTION

Availability of viable seeds to farming households is an important undertaking. According to Louwaars, (1994) and Cromwell, (1996), most farmers still use archaic ways to obtain seeds for their agricultural practices. In most developing countries small scale farmers' use seeds saved from harvests of previous seasons. About 60-70 per cent of seed used by small scale farmers in developing countries is still saved on-farm. Most of the remaining seed is obtained from local sources, off-farm. In addition, not all farmers can afford to buy improved seed supplied by the organized seed industry from the agro-vets. For many farmers, such seed is not available, even if they wanted it and could afford it. In actual fact, the majority of the world's farmers, and crops, are not planted from such seed but from Home-saved seeds which are treated using traditional methods such as smoking and dusting with ash.

According to USDA (2013) report, the average world grain yield in 1950 was 1.1 tons per hectare. By 2011, it had increased to 3.3 tons per hectare. The challenge for all policy makers and researchers is to continually improve and maintain this yield per hectare because of the ever increasing world population which largely depends on food grain. The world population is currently rising rapidly. Virtually the same amount of arable global farmland is expected to support this increasing number of people. In an attempt to improve and increase food security, efforts should be geared towards increasing yield per unit area of land. Some of the ancient seed treatments are use of sap from onion and extract of cypress during Egyptian and Roman reigns. Salt water treatments has been used since the mid-1600s while the first copper products were introduced in the mid-1700s. In addition to these was employment of arsenic, which was used between 1740 and1808. Mercury was used from 1915 up to 1982. Until 1960s seed treatment largely made use of surface disinfectants and protectants. The first systemic fungicide product was launched in 1968. This systemic fungicide ,in addition to seed surface activity, penetrated inside into plants hence protecting young seedlings from airborne pathogens. Since 1990s crop protection and seed industries have developed and availed new classes of fungicides, insecticides, and nematicides chemistries, expanding pest control while reducing unwanted user and environmental impacts, and as such ensuring sustainability. The seed and seed treatments industries have a long history of partnership and dedication aimed at providing growers with high quality seeds. Today seeds must be as pest- and disease-free as possible and treatment must provide protection against pests and diseases during germination, emergence and growth of the plant, (IFS, 2007).

For centuries seed treatment technologies have been used in cereals, mainly in an attempt to control seed borne diseases that become a nuisance and cannot be effectively controlled later in the crop's development stage. Diseases such as wheat bunt (tilletia tritici) and leaf stripe of barley (pyrenophora graminea) have been well controlled since the introduction of organomercury in the 1930's when seed-borne diseases like bunt and leaf stripe were common. Modern seed treatment technologies now offers very safe and environmentally friendly alternatives to mercury. Following the availability of safe and cost-effective seed treatments, the UK farming industry embraced the technologies and seed treatment became a common practice among UK farmers. Compared with the cost of foliar fungicides, fungicidal seed treatments have always been relatively cheap. However, with increasingly sophisticated seed treatment technologies available, the cost of treatment became significant and some farmers began to question the need for seed treatment in all cases (Clark and Cockerill, 2011)

There has been tremendous breakthrough in coming up with Seed-dressings, which are permitted in organic farming. In Germany Tillecur, which is based on mustard flour, is used. This agent is effective against bunt (tilletia tritici) (Borgen and Kristensen 2001, Spiess 2000). Experiments with acetic acid (vinegar) as a seed treatment have been carried out and shown to be effective against bunt and leaf stripe (Borgen and Nielsen 2001). Due to the present interpretation of the EU regulations this agent, along with vinegar, is not permitted as a seed treatment option.

According to Gastel et al., (2001), for wheat seed production, the future is uncertain. Wheat is a high-volume, low-profit seed crop and has been produced primarily under heavily subsidized government seed programmes. With privatization and liberalization, many of these programmes are at risk of collapse. The private sector, however, may not focus on wheat seed due to its characteristics (self-pollinating, high-volume and low-profit). If private seed enterprises exist, they consider wheat seed to be of secondary importance. Furthermore, wheat farmers in most countries have no on-going efforts to promote use of improved seed, and no significant breeding developments have recently taken place to increase yield and quality. Since wheat is a self-pollinating crop and grain can be used as seed, farmers tend to replant their own seed. It is, therefore, expected that in future a large majority of resource-poor, small-scale farmers in many developing countries will have to rely on seed saved from previous harvests.

The rate of new agricultural technology uptake in Kenya as been relatively low due to several bottlenecks, key among them as per GOK, (2010) report being: weak research-extension-farmer linkages, low funding ;and inadequate field staffing levels ;and inadequate promotion and marketing of new varieties and complementary technologies by private sector. The establishment of KSC in Kitale in 1956 was the initial mark of the formal seed system in Kenya. The company was established to produce pasture seed for the immigrant farmers (Sikinyi, 2010). Today, the formal system comprises of specialized organizations in the public and private sector ,involved directly or indirectly (regulatory agency) in breeding, multiplication, quality control, processing, storage, marketing, and distribution of seed. The formal seed system supplies strictly regulated certified seeds of improved varieties and accounts for 20% of seeds sown in Kenya (Sikinyi, 2010). The informal seed system is still a major seed source in Kenya. It provides seeds without quality control and supplies 80% of the seeds for planting purposes in the country (Sikinyi, 2010). According to MOA, the informal seed sources include road-side nurseries, farm-saved seed, farmer-to-farmer exchange, local markets, NGOs and CBOs. Seed provided by relief agencies are sometimes obtained from non-registered seed dealers with unknown quality (Sikinyi, 2010). A number of NGOs are establishing private companies to supply small scale farmers with certified seed.

Gamba et *al.,* (2003) found out in their study that 56% percent of small-scale farmers and corresponding 49% percent of large scale farmers obtained wheat seeds from other farmers. Most small scale farmers, they observed, (50%) obtained seeds in the same village although about 35% travelled more than 10 Km to get the seed. About 59% of large scale farmers travelled more than 10 Km to get seed, while 28% obtained seed from the same village.

According to ISF, (2007), modern seed treatment products offer control of target pests and diseases and in the process ensure the establishment of healthy and vigorous plants. Their formulation and industrial application also contribute to improvement in growers' and workers' safety and stewardship of the environment, thus achieving environmental sustainability. Today's modern seed treatment products being introduced to the market have to meet not only efficacy standards but also safety and environment standards. The latest active substances and formulations provide long-lasting, broad spectrum, control of pests and diseases. Modern formulated seed treatment products are precisely blended products consisting of several active ingredients, special wetting agents, colorants and sometimes bird repellents which are rigorously tested for their safety to the seed, the users and the environment.

According to Hassan *et al.,* (2016), results showed that all farmers use improved wheat varieties but with a big variation in; sources of wheat seed, seeding rate, and sowing. About 50% of farmers use their own seed, and only 15% of those who bought seed for cash acquired it directly from Kenya Seed Company. Their study further concluded that the remaining farmers purchased seed from merchants and other farmers. Understanding the behavioral patterns of the farmers who acquire seeds from other sources which are not certified would thus be of

interest in addition to insights into how they better their seeds in an attempt to improve their farm productivity. This objective can be achieved through treating the seeds chemically. With time transformation has been realized and the formal system now comprises a number of specialized organizations in the public and private sector who are involved directly or indirectly in breeding, multiplication, quality control, processing, storage, marketing, and distribution of seeds. The formal seed system supplies strictly regulated certified seeds of improved varieties accounting for 20% of the seeds that reach the farmers in Kenya. In an attempt to eliminate uncertainty, most farmers still rely primarily on farmer-to-farmer exchanges or saved seed (Delay, 2004). However, surveys such as these are often unable to provide real insights into the improved seed adoption due to problems in their design. According to Doss *et a.,* (2003), the pertinent issue should be; what type of variety is a farmer cultivating and when did he or she purchase the seed. In cases of improved open-pollinated varieties such as wheat, farmers do not necessarily need to purchase seed every season as they should with hybrid maize. Rather, they might purchase seed every 4-5 years to replace their stocks of saved seed with seed that has a higher level of purity, and thus better performance when cultivated.

The quality of seeds available to farmers to a great extent determines the cost of production. The quality of wheat seeds has raised some concerns among wheat producers. Some certified wheat varieties available are contaminated with other seeds. This has led majority of farmers to use retained or non-certified seeds, and selected and treated seeds from their neighbors. Most of these seeds may not be treated. Some farmers are now forced to invest in seed drying and treating plants, thus, developing the market further for uncertified treated seeds, (Nyoro et *al.,* 2001). The study by Gamba et *al.,* (2003) captured this phenomenon when they found that 63% of small scale farmers and 66% of large scale farmers attached importance to cleaning their wheat seeds before planting. They also found that only 59% of small scale farmers dressed their seeds, with only 52% of their respective large scale farmers doing so. It would be of great economic importance to understand the dynamics of seed chemical treatment by the farmers so as to ensure increased productivity at farm level in wheat production in Kenya. It was from this perspective that this study aimed at analyzing the determinants of adoption and extent of uptake of seed care technologies of Home-saved wheat seeds in Kenya.

II. THEORETICAL FRAMEWORK

This study was guided by the adoption theory developed by Everett Rogers in the early 1930s. The adoption theory is an alternative theory to the Theory of Task-technology fit (TTF), the Theory of Reasonable Action (TRA) and the Theory of Planned Behavior (TPB) (Lai, 2016) which the researcher felt cannot suffice because of their emphasis on limiting determinants to uptake of advanced technology. The only meaningful way to study individuals technological adoption is diffusion innovation approach which incorporate diverse socio-economics, institutional and attitudinal factors of the respondents as well as the characteristic of the technology to be adopted. Rodgers proposed that the theory of 'diffusion of innovation' was to establish the foundation for conducting research on innovation acceptance and adoption. Rogers synthesized research from over 508 diffusion studies and came out with the 'diffusion of innovation' theory for the adoption of innovations among individuals and organization. The theory explicates "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995). Basically, it's the process of the members of a social system communicating an innovation through certain channels over time known as diffusion. The diffusion of innovation theory explained that the innovation and adoption happened after going through several stages including understanding, persuasion, decision, implementation, and confirmation that led to the development of S-shaped adoption curve of innovators, early adopters, early majority, late majority and laggards as shown below.

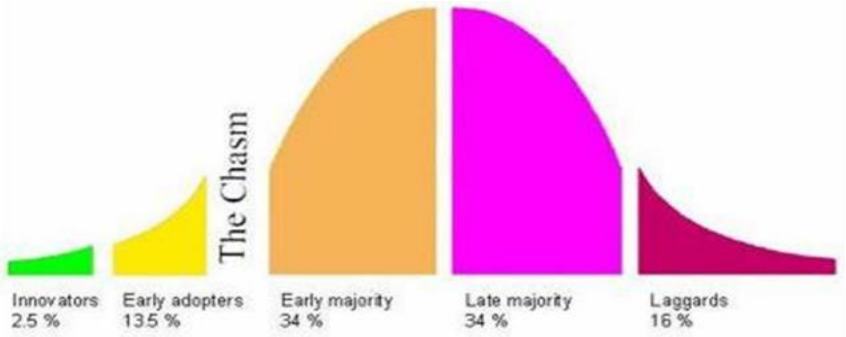

Figure 1: Innovation Adoption Curve (Rogers, 1995)

Determinants of adoption are outlined clearly and they can be classified as follows: 1) innovators who are educated and venturesome; 2) early adopters who are popular ,educated and are normally social leaders; 3) early majority who are deliberate and have many social contacts; 4) late majority who are very skeptical; 5)

laggards who are traditional and normally of lower social economic class (Rogers, 2003). He outlined them as being dependent on perceived attributes, of which comparative advantage or the degree to which an innovation is perceived better than the idea it supersedes is first taken into account. Other issues of attributes that he outlined are: complexity (the degree to which a practice is perceived as relatively difficult to understand and to adopt, negatively related to its rate of adoption), trial-ability (degree to which an innovation may be experimented at a limited basis) and compatibility (degree to which sustainable practice is perceived as consistent with the existing values, past experience and needs of potential adopters. Rogers, (2003) further described innovation process as a process through which an individual passes from; knowledge to attitude and finally to adopting (individual or collective, optional or authority). He further pointed out the importance of communication channels in innovation process defining them as interpersonal or mass media, originating from specific or diverse sources. He also defined social system as norms, network interconnectedness pointing out that these socio-cultural practices and norms can inhibit or drive adoption. He stated that efforts of promotion agent in the past and present are important. The current study drew similarity with this theory to study factors influencing the use of chemical treatment on Home-saved wheat seeds among wheat farmers in Kenya.

There exist vast literatures on factors that determine agricultural technology adoption. According to Adebiyi, (2013), farmers' decisions about whether and how to adopt new technology are conditioned by the dynamic interaction between characteristics of the technology itself and the array of conditions and circumstances. Diffusion itself results from a series of individual decisions to begin using the new technology, decisions which are often the result of a comparison of the uncertain benefits of the new invention with the uncertain costs of adopting it (Khanna, 2012). An understanding of the factors influencing this choice is essential both for economists studying the determinants of growth and for the generators and disseminators of such technologies (Khanna, 2012).

Traditionally, economic analysis of technology adoption has sought to explain adoption behavior in relation to personal characteristics and endowments, imperfect information, risk, uncertainty, institutional constraints, input availability, and infrastructure (Uaiene, 2009). A more recent strand of literature has included social networks and learning in the categories of factors determining adoption of technology (Uaiene, 2009). Some studies classify these factors into different categories. For example, Akudugu *et al*., (2012) grouped the determinant of agricultural technology adoption into three categories namely; economic, social and institutional factors. Kabede et *al*., (1990) as cited by Lavison, (2013) broadly categorized the factors that influence adoption of technologies into Social, Economic and physical categories. McNamara, Wetzstein and Douce (1991) categorized the factors into, farmer characteristics, farm structure, institutional characteristics and managerial structure, Nowak (1987) grouped them into informational, economic and ecological, while Wu and Babcock (1998) classified them under human capital, production, policy and natural resource characteristics. Although there are many categories for grouping determinants of technology adoption, there is no clear distinguishing feature between variables in each category. Categorization is done to suit the current technology being investigated, the location, and the researcher's preference, or even to suit client needs (Bonabana- Wabbi 2002). For instance the level of education of a farmer has been classified as a human capital by some researchers while others classifies it as a household specific factor.

III. RESEARCH METHODOLOGY

Study Area

The study was conducted in Uasin Gishu County. It measures 3,328 km^2, Uasin Gishu County borders Kericho County to the south, Nandi to the South-west, Kakamega to the West, and Trans Nzoia to the North. It has its headquarters in Eldoret which doubles up as its commercial centre. The County has six sub counties namely; Moiben, Kesses, Kapseret, Anaibkoi, Turbo and Soy. According to the 2010 census, Uasin Gishu has a population of 894,179 with 202,291 households and a population density of 269 people per square km. The age distribution is 0-14 years 41.5 %, 15-64 years 55.7%, and above 65 years 2.9%. A young population signifies a high level of dependence, especially to cater for such needs as education and health (Uasin Gishu County website). Estimated 90 percent of the entire land area in the county is arable and can be classified as high potential. There are four major soil types in the area, all of which are suited for agricultural production. These include red loam, red clay, brown clay and brown loam. The poverty level in the county stands at 49% (KNBS, 2007) with forty percent (40%) of this being rural based while 54% is urban. The main economic activity is farming mainly Maize, wheat and dairy cattle rearing.

Population and sampling

According to Uasin Gishu County Annual Report (2017); there are approximately 3,632 wheat farmers across the six sub counties. In this study, all 3,632 wheat farmers were targeted. A multistage proportional -to -

size cluster sampling involving four stages was followed. In the first stage, Uasin Gishu County was purposively selected for this study since it iss one of the food baskets in Kenya. It is also the county with a high number of wheat farmers practicing both small and commercial wheat farming. In stage two, wheat farmers were clustered into six strata based on their Sub Counties as follows; Moiben, Kesses, Kapseret, Ainabkoi, Turbo and Soy. In stage three, number of farmers in each cluster was obtained by determining the proportion of total number of wheat farmers in each Sub County against the computed sample size of 101 wheat farmers. In the final stage, wheat famers were picked systematically at an interval of five in each of the six sub counties.

Survey technique

This study used questionnaire guided survey technique. Researcher with the help of three trained enumerators administered the research questionnaires to collect information from wheat farmers in Uasin Gishu County. The questionnaire for this study was divided into four main sections, namely; Section A contained the Socio-demographic characteristics, Section B constituted the economic factors; Section C institutional factors and section D comprised of technological factors.

Analytical Framework

Double Huddle model

A double-huddle model as previously used by Sunday *et al.,* (2013) was employed to examine the factors which influence the adoption decision and the extent of uptake of seed care technologies of Home-saved wheat seeds.

The study used the independent double-hurdle model with the assumption that access to and extent of adoption of seed treatment of Home-saved wheat seeds by farmers were two distinct or independent decisions. Each hurdle tier was conditioned by the wheat farmers' socio-economic, technological, and institutional characteristics. The zeros reported in the first-stage arose from the farmers who did not seed dress their Home-saved wheat seeds; and those in the second hurdle came from zero land under seed dressed Home-saved wheat seeds due to farmers' deliberate decision or random circumstances.

The first hurdle was a binary outcome whether the farmers adopt seed treatment of Home-saved seeds technology or not , estimated with the normal Probit model.

The wheat farmers were partitioned into two strata, those who practiced seed treatment of Home-saved wheat seeds ($S_n > 0$) and non-adopters ($S_n = 0$). Where; S_n denoted land in acres under seed dressed Home-saved wheat seeds and y_1 represented the category of wheat farmer, since the adopters and non adopters' partitions yielded an ordered response. Let the ordered response y_1 be such that;

$y_{1i} = 0\ if S_{ni} = 0$ (1)

$y_{1i} = 1\ if S_{ni} > 0$ (2)

Where the index equation is written as;

$y_1^* = \beta_{1i} X_{1i} + \varepsilon_{1i}$ (3)

In this case, y_1^* was the latent discrete adoption choice decision variable that denoted a binary censoring, which was the utility the farmers derived from adopting the seed treatment of Home-saved wheat seeds technology; X_{1i} was a vector of explanatory variables hypothesized to influence seed care technology adoption decision by wheat farmers; β_{1i} was a vector of parameters and ε_{1i} was the stochastic term.

The threshold index equation for the binary model was stated as;

$$y = \begin{Bmatrix} 1\ if\ the\ farmer\ adopt \\ 0, if\ the\ farmer\ did\ not\ adopt \end{Bmatrix} (4)$$

.

Finding the determinants of extent of adoption was achieved by estimating the equation of the second hurdle. The second hurdle involved an outcome equation, which employed a truncated Tobit model to determine factors affecting the actual land size under the seed dressed Home-saved wheat by the farmers. This stage used the observations only from respondents who adopted the seed care technology of Home-saved wheat seed technology. The truncated model, which closely resembles Tobit's model, specified as;

$Y_2^* = X_{2i}'\beta_2 + v_i\ , v_i N(0, \delta^2)$ (5)

Where Y_2^* is the observed land size under the seed dressed seeds by the farmers who seed dressed their Home-saved wheat seeds. For the farmers who did not seed treat their Home-saved wheat seeds, Y_2^* was not measured and was set to be equal to zero (0).

IV. RESULTS AND DISCUSSIONS

Socio-demographic characteristics

The study showed that majority of the farmers, 91.1% were male, while only 8.9% were female. The probable reason was that men being heads of households control virtually all household resources. The study

revealed that most of the wheat farmers have primary level of education (50.5%) followed by secondary education (31.7%), college education (13.9%) and university education (4.0%). The reason for this statistical spread could be that farming is the main economic activity which attracts people of all cadre of education in this region; and thus the proportional mix runs close to real population classal mix. The study showed that most wheat farmers are married (84.2%) followed by the widowers (6.9%), widows (5.0%) and lastly the singles (4.0%). Wheat farming is laborious in nature and therefore practiced by married people in order to provide adequate domestic labor required during the wheat production processes. The results showed that most of the wheat farmers were elderly people with a mean age of 47.83 years, minimum age of 24 years, maximum age of 75 years and a standard deviation of 11.283 years. This signified that the younger generation preferred other sources of income generation other than wheat farming in the region. Elder people have tight budget obligations resulting from bringing up families than do the young people. The study revealed that average wheat farmers' households sizes comprised of 6 members with a standard deviation of 2.455. The minimum number of wheat farmers' household constituted of one member while the maximum composed of 12 members. The large size of the household provided the labor force required for wheat farming practices.

Table 1: Socio-demographic characteristics

Description	Frequency (f)	Percentage (%)
Gender of the respondent		
Male	92	91.1
Female	9	8.9
Education level of respondent		
Primary	51	50.5
Secondary	32	31.7
College	14	13.9
University	4	4.0
Marital status of the respondent		
Married	85	84.2
Single	4	4.0
Widow	5	5.0
widower	7	6.9

Description	Range	Min	Max	Mean	Std. Deviation
Age of respondent	51	24	75	47.83	11.283
Household size	12	1	13	6.34	2.455
Farmer experience	38	2	40	16.32	9.063

Source: Survey data, (2018)

Technological and Institutional characteristics

The study results showed that majority of the wheat farmers (81.2%) were aware of seed treatment while 18.8% were not aware. The respondents who were aware sourced information from seminars, field days, barazas and from extension officers. Majority of farmers did not seed dress their Home-saved wheat seeds (68.3%) while 31.7% seed dressed their Home-saved wheat seeds. The main reasons why most farmers did not seed-dress their seeds included high cost of chemicals required, lack of Seed-dressing machines and inability to access Seed-dressing equipment. In terms of seed cleaning, 73.3% of respondents cleaned their Home-saved wheat seeds while 26.7% did not clean. Some of the reasons negating included lack of modern cleaning equipment and high cleaning costs charged by mobile cleaning agents. The study showed that majority of wheat farmers purchased commercial wheat seeds (82.2%) and only 17.8% did not purchase commercial wheat seeds. The commonly purchased wheat seeds include KSC Mwamba, Njoro II, Eagle 10, Farasi, Kenya Hawk, Robin and Pasa.

The study revealed that most of the wheat farmers did not have access to formal credit facilities (87.1%), while only 9% of wheat farmers had access to formal credit facilities. Wheat farmers accessed credit facilities from various sources including commercial banks, co-operatives, microfinance institutions, Agricultural finance corporation and input suppliers among others. Regarding access to extension services, the results showed that majority of the wheat farmers (64.4%) did not receive extension services while 35.6% of the farmers received extension services. The main source of extension services offered in the region, is governmental through the ministry of Agriculture in all the sub counties in Uasin Gishu County. However, some wheat farmers also get extension services from farmer's co-operatives, private firms and from non-governmental organizations sponsored programmes.

Table2: Technological and Institutional characteristics

Description	**Frequency (f)**	**Percentage (%)**
Seed care treatment awareness yes, no	(81,19)	(81.2, 18.8)

Seed-dressing yes, no	(32, 69)	(31.7, 68.3)
Cleaning of seeds yes, no	(74, 27)	(73.3, 26.7)
Purchase of commercial seeds yes, no	(83, 18)	(82.2, 17.8)
Credit access, yes, no	(13, 88)	(12.9, 87.1)
Extension services accessibility yes, no	(36, 65)	(35.6, 64.4)

Source: survey data, (2018)

Econometrics

The study employed the use of Cragg (1971) Tobit alternative model since it was assumed that the farmers' decision to adopt seed treatment of Home-saved wheat seeds, and the subsequent extent of application of this technology were mutually exclusive. The test statistics showed that the Cragg's model had an overall strong significant (chi2 (1) = 621.174 Prob p-value = 0.000) at one percent level of significance. Following Roodman, (2009), the study revealed that the two decisions; of adoption of seed care technologies of Home-saved wheat seeds and the extent of their application were indeed independent from each other as shown in the **Table 3**, below for the dual tiers of decisions: adoption decision and extent of adoption decision.

Determinants of adoption decision of seed care treatment of wheat seeds

The study showed that various factors influenced the adoption decision to seed treat Home-saved wheat seeds in Kenya. Some of the determinants comprised gender, education level, household size, access to extension services, land tenure and distance from farm to the nearest seed treater.

Gender of wheat farmers revealed a positive significant (p-value=0.00) at one percent significance level. This showed that male farmers had high likelihood to practise seed treatment of wheat seed in Kenya than their female counterparts. In most of the wheat farming households, men are the household heads who make farming decisions and control family assets, unlike women. A similar finding was obtained by (Mignouna et al., 2011 and Bonabana-Wabbi, 2002). However, Moris and Doss, (1999) found no significant association between gender and probability to adopt improved Maize in Ghana.

Education level of wheat farmers had a strong positive significant (p-value=0.00) at 1% significance level as was in the priory. The likelihood of wheat farmers in Kenya to adopt seed care technologies of Home-saved wheat increases with education level. The study revealed that farmers with higher education levels were aware of more sources of information, and more efficient in evaluating and interpreting information about seed care of wheat seeds than those with less education. The study was in agreement with the (Abay and Assefa, 2002 and Teklewold*et al.,* 2006) who also found positive relationship between education and adoption of improved agricultural technologies.

Household insignificant (p-value=0.00) positive association of decision to treat Home-saved wheat seeds as was hypothesized in the priory. It was evidenced that the likelihood of adoption decision increases with the increase in the number of the household size. This indicated that larger families were more likely to be involved in wheat seed treatment of Home-saved seeds because of the availability of enough manpower.

Access to extension services showed positive significant (p-value= 0.04) association with the adoption decision of the seed treatment of Home-saved wheat seed at 5% significance level. The likelihood of adoption decision increases with the wheat farmers' accessibility to extension services. The main source of extension services offered in the region was provided by the government through the ministry of Agriculture in all the sub counties in Uasin Gishu. A similar finding was obtained by (Karki& Bauer, 2004; Oladele, 2005;Uaiene *et al.,* 2009; Akudugu*et al.,* 2012 and Genius *et al.,* 2013).

The study showed that Land tenure had a negative significant (p-value 0.02) ,with the adoption decision of seed treatment at 5% significance level. The finding was against the expected positive relationship between land tenure and adoption of seed treatment of wheat seeds in Kenya. The results implied that the likelihood of adoption decision of seed treatment of wheat seeds declined as owned land tenure increases among the wheat farmers in the region. The leased and shared crop type of land tenure wheat farmers had profit maximization objective, good marketing channels and information pertaining wheat farming which made them to adopt the seed care technologies of Home-saved wheat seeds more than the farmers who carried out wheat production on their own farms. Nevertheless, study by Uaiene et *al*., (2009) found contrary result showing that own-land tenure farmers adopt new agricultural innovation more than the leased farmers.

Out of the ten variables hypothesized to influence the adoption decision of seed care treatment of wheat seeds in Kenya, four variables had insignificant relationship with the adoption decision. The variables comprised of age, land size, access to extension and cleaning of wheat seeds.

Determinants of extent of adoption of seed care treatment of wheat seeds

The findings indicated several factors significantly influence the extent of adoption of seed care t of Home-saved wheat seeds. The determinant include total land size, availability of wheat seed treatment equipment, expected better wheat prices, access to credit and gross income from wheat production.

The variable total land owned by the farmers had a positive significant (p-value=0.00) with the extent of seed care treatment of wheat seeds at 1% significance level. The farmers who had relatively large farm sizes were more inclined to a large extent towards adoption of seed care technologies of Home-saved wheat seeds than those with small parcels of land. This was due to the fact that farmers with large farm sizes are likely to adopt new technologies as they can afford to devote part of their lands for trials unlike those with less farm sizes. Study by (Gabre-Madhin and Haggblade, 2001 Ahmed, 2004; Uaiene*et al*., 2009 and Mignouna et al, 2011) found the same positive association between land size and technological adoption of improved agricultural practices. Nevertheless, some adoption studies found no relationship between land size and the extent of adoption of improved agricultural technologies (Mugisa-Mutetikka et al., 2000, Bonabana- Wabbi 2000 and Samiee*et al.*, 2009).

The variable availability of treatment equipment had a positive significant (p-value=0.00) influence of the extent of seed care of Home-saved wheat seeds at 1% significance level. The wheat farmers with access to wheat treatment equipment had high extent of adoption of the seed treatment technologies of Home-saved wheat seeds than the non-accessed farmers. This study finding was similar with that of Foster and Rosenzweig, (2010) who found a positive association between farmers' access to subsidized agricultural machinery and the adoption of innovative agricultural processing technique.

Concerning expected better wheat prices in the future, the study found a positive significant (p-value=0.00) relationship with the seed treatment of Home-saved wheat seeds. Wheat farmers who perceived future wheat prices to be favorable showed higher extent of adoption of seed treatment technologies of Home-saved wheat seed then those who perceived-expected low prices. This means that farmers were more inclined to adopt seed care technologies of Home-saved wheat seeds, if price expectation was higher at the end of the season. Diiro and Sam, (2014) also found out a positive influence of expected future prices on adoption of agricultural technologies.

The variable credit access had a positive a significant (p-value =0.01) effect on the extent of seed care treatment of Home-saved wheat seed since credit accessibility give farmers better opportunities of getting wheat treatment equipment. Farmers who had access to formal credit were more probable to extent the adoption of seed care treatment of Home-saved wheat seeds than those who had no access to formal credit. On the other hand the availability of farm credit especially from formal sources such as commercial banks, Agricultural finance corporation and co-operative societies were vital components of the modernization of seed care of Home-saved wheat seeds so as to increase productivity. This indicates that smallholder wheat farmers cannot finance this equipment for seed treatment unless they get alternative means. Adoption studies with similar findings were those of (Yishak, 2005; Simtowe and Zeller, 2006; Mohamed and Temu, 2008 and Muzari*et al.*, 2012).

The variable off-farm income had a positive significant (p-value=0.00) relationship on the extent of adoption of seed treatment technologies of Home-saved wheat seeds at 1% significance level. The off- farm income provide the wheat farmers access to ready capital for purchasing productivity enhancing inputs such as seed care equipment, fertilizers among other farm inputs. Adoption studies with the same positive association of intensity of adoption of improved agricultural technologies include (Ouma*et al.*, 2002; Wekesa*et al.*,2003; Reardon *et al*., 2007; Ellis and Freeman, 2004; Diiro, 2013). However, some adoption studies showed an inverse association between off-farm income and extent of technological adoption of improved agricultural practices (Goodwin and Mishra, 2004).

Table 3: Double hurdle model maximum likelihood estimate on determinants of uptake of seed care treatment for Home-saved wheat seeds.

Variables	Coef.	Std.Err.	Z-stat	Sig.
Adoption decision				
LnAge	0.02	0.01	1.37	0.17
Gender	0.37	0.06	5.72	0.00***
EDUC	2.42	0.89	2.76	0.00***
LnFSIZE	1.03	0.25	4.14	0.00***
LnSLAND	0.34	0.21	1.62	0.12
CACCESS	0.05	0.19	0.27	0.75
ESERVICE	0.10	0.05	2.00	0.04**
DISTREAT	0.11	0.02	5.49	0.00***
SCLEAN	0.04	0.27	0.15	0.67
LTENURE	-0.70	0.30	-2.33	0.02**
-Cons	-0.60	0.59	-1.02	0.31
Extent of Adoption				
LnAge	0.08	0.33	0.24	0.81
Gender	1.13	2.14	0.53	0.60
LnSLAND	0.23	0.07	3.18	0.00***
EDUC	0.20	0.40	0.48	0.62
ATMNTEQUP	0.16	0.06	2.67	0.00***
EPRICE	0.29	0.09	3.49	0.00***

InYLD	1.3	0.94	1.37	0.18
FSIZE	0.02	0.01	1.38	0.16
CACCESS	0.19	0.08	2.38	0.01**
LnOff-INCOM	0.36	0.05	7.19	0.00***
-cons	27.60	7.76	3.57	0.000

Number of obs = 33 Wald Chi2 (28) = 172.64; Log pseudo likelihood = -682.36 Prob> chi2 = 0.00; ***, ** and * indicate 1, 5 and 10% level of significance respectively.
Source: Survey data, (2018).

V. CONCLUSION

The study found out that there are various social, economic, technological and institutional factors which influence the farmers' adoption decisands and extent of adoption of Home-saved wheat seeds in Kenya. The major significant determinants of farmers' adoption decision of seed treatment technologies of Home-saved wheat seeds comprised of gender, education level, household size, access to extension services, land tenure and distance from home to nearest seed treater. The variables gender ,household size, access to extension services and distance from home to the nearest seed treater had a positive effect on the farmers' adoption decisions for seed treatment of Home-saved wheat seeds. However, the variable land tenure had a negative influence on farmers' adoption decision of seed treatment of Home-saved wheat seeds in the region despite being significant at 5% significance level. Other hypothesized variables such age, credit access, total land size and seed cleaning were not statistically significant at 1, 5 and 10% significance levels. These determinants had minimum influence on the wheat farmers' adoption decision of seed treatment technologies of Home-saved wheat seeds in Kenya.

The second tier of the double hurdled model examined the determinants of the extent of seed treatment of Home-saved wheat seeds. The study revealed that several social, economic; technological and institutional factors had effect on the farmers' extent of seed treatment of Home-saved wheat seeds in Kenya. Some of the significant determinants include total land size, off-farm income, availability of treatment equipment and access to credit facilities. The study findings showed that all the determinants had a positive influence on the extent of treatment Home-saved wheat seeds. Out of the ten hypothesized determinants, five were found to be insignificant. The variables include age, gender, education, yield and household size. The study revealed least association of these variables on the extent of seed treatment of wheat seeds in the region.

Pertinent recommendations emanated from this study. Given the positive significant influence of education on the adoption of seed care treatment, the government through the ministry of agriculture at County levels should provide more trainings, open field days and demonstration centres for farmers to gain knowledge on seed treatment of home-saved wheat seeds. The imitative will help farmers to increase their production, eradicate challenges of prolonged seed dormancy and prevent destruction of seeds by pests as well as reducing seed rate requirement per hectare.

Findings showed positive significant effect of extension services on adoption of seed treatment of Home-saved wheat seeds; the government should strengthen various extension channels through motivation of extension staffs, employment of additional extension officers, increasing the frequency of extension visits, providing adequate means of transport for extension bureaucrats and decentralization of extension service stations to village levels. These measures will help the farmers to acquire relevant agricultural practices which will translate to food security of Kenyans, since the region is one of the bread baskets of the country. The current extension officer to farmer ration stand at 1:1500. This large ratio of extension staff to farmers is one of bottleneck hindering dissemination of modern agricultural practices to medium and small scale farmers in Kenya.

County government of Uasin Gishu should provide farmers with seed treatment equipment so as to increase extent of adoption of seed care technologies of Home-saved wheat seeds in the region. The stockiest should also avail chemicals required for seed care of Home-saved wheat since most farmers claimed they could not easily access them when needed.

Given that expected better wheat prices in future had a significant positive connotation on extent of adoption of seed treatment of Home-saved wheat seeds, the government should provide price incentive measures to wheat farmers through favorable interventions leading to high wheat prices above market prices at the end of each production season. This will enable farmers to acquire essential farm inputs as well as modern wheat treatment equipment.

Since access to credit facilities also had a positive significant effect on the extent of adoption of seed treatment of Home-saved wheat seeds, Commercial banks and other lending institutions should relax their tedious lending policies like strict collateral requirements, high interest rates and strict repayment terms especially as expected from medium and small scale farmers. This initiative will enable farmers to acquire more credit which is a principle component of uptake and extent of adoption of modern agricultural practices by both medium and small-scale farmers in the region.

Based on the positive significant association of off-farm income on the extent of adoption of the seed treatment technology, financial institutions, NGOs and the government should provide entrepreneurial trainings to farmers in the region to enable them diversify sources of income.

Finally, the study recommend provision of wheat farmers with seed-dressing and seed-cleaning machines by the government, commercial seed companies, commercial chemicals companies and Non Governmental Organization (NGOs) in the region so has to enhance uptake of seed treatment technologies of home-saved wheat seeds by farmers in Kenya.

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