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Adopting new banana varieties in Uganda: the role of gender and head of household status

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ABSTRACT

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Recognizing the gender gap that exists in the adoption rates of improved agricultural technology is crucial in increasing agricultural productivity in Sub-Saharan Africa. A gender-disaggregated framework is used to examine key variables that guide the adoption decision of improved agricultural technologies by gender and household headship. Drawing on household data collected in two districts in Uganda and constructing a probability model, key variables will be analyzed as to their significance in the adoption decision for improved banana cultivars. The analysis shows that gender alone is insufficient in fully understanding adoption decisions, as other significant factors exist. Using the literature and primary data, key variables will be analyzed to determine the constraints that female farmers face which limits adoption decisions. Determining the significant variables in adoption of improved agricultural technologies has policy implications that suggest research studies ought to focus on equitable resource availability to reduce the gender gap in agricultural technology adoption, which will in turn improve agricultural productivity.

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DEDICATION

I would like to dedicate this paper to all my friends and family who supported me while writing this paper and in my graduate career.

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1. Introduction

Women consist of 50% of the agricultural labor force in Sub-Saharan Africa and do not have equal access to the resources and opportunities needed to be more productive (FAO, 2011). Many Sub-Saharan African countries have low agricultural productivity, and increasing productivity leads to increased food security, well-being and improved livelihoods. However, there is a gender gap in productivity (Peterman et al., 2010; Quisumbing, 1996; De la O Campos et al., 2016), which is due to lower access to inputs and resources rather than efficiency or management styles (Quisumbing, 1996; and Gladwin et al, 2003).

An important resource for increasing agricultural productivity is the adoption of improved agricultural technologies, such as improved seed varieties (Minten & Barrett, 2008). Studies have shown that men and women adopt new technologies at different rates, and there are many different indicators that lead to this difference. While researchers and development practitioners might find it difficult to design technologies to meet the needs of all potential users, appeals by donors and activists for gender equity and gender mainstreaming in the agricultural sciences means that researchers and policy makers need to consider how gender influences the adoption of new agricultural technologies.

This paper seeks to answer key questions in this regard in the context of the introduction of improved banana varieties, or cultivars, in Uganda. First, to what extent does a farmer's gender and household status determine adoption of improved banana varieties? This will be considered through the construction of a probit model. Second, given that a farmer's gender or headship status has significance to explain the adoption of improved banana cultivars, what factors and constraints lead to the adoption decision? Considering these questions, gender and head of household can be further examined in impacting the different rates of adoption between male and female farmers. Recognizing these differences are important for researchers and policy makers in project design and implementation of improved seed varieties, to understand the constraints and equalize the adoption rates between male and female farmers.

After reviewing the literature on gender and agricultural technology adoption, I draw on primary data collected in summer 2015 to show the extent to which gender and other key variables affect adoption rates. This paper has been structured as follows. Section 2 begins with an overview of bananas in Uganda, and a discussion about improved varieties that have already been introduced in Uganda. The data collection and research methods provide an overview of the materials used (Section 3). In Section 4 will explain the construction of the probit model, and Section 5 will discuss the key variables that influence adoption rates. Section 6 will analyze the results and significant variables in further detail.

2. Bananas in Uganda

Uganda is the largest banana producer and consumer in Sub-Saharan Africa (IITA, 2009). In Uganda, banana, or *matooke*, is consumed at a daily rate of between 1-2lb/person, and constitutes around 20-30% of the crop acreage under cultivation (Karamura, D.A. et al., 2012). Millions of Ugandans rely on banana as part of their livelihoods and daily dietary requirements, with approximately 75% of farmers cultivating banana (Nowakunda & Tushemereirwe, 2004; Jogo et al, 2013). Banana is a perennial crop, and requires approximately 18 months to yield fruit, but fruit can be harvested throughout the year (IITA, 2009). The banana plant can also produce fruit up to 100 years (ibid).

Since 1990, banana yields have decreased by more than 8% (Figure 1), even though area that is under cultivation has increased by about 10% (Figure 2). Decreases are due to pests and diseases. A significant disease to banana production, black sigatoka, can reduce yield by 50% and reduce the longevity of banana farms from 30 years to two years (Craenen, 1998).

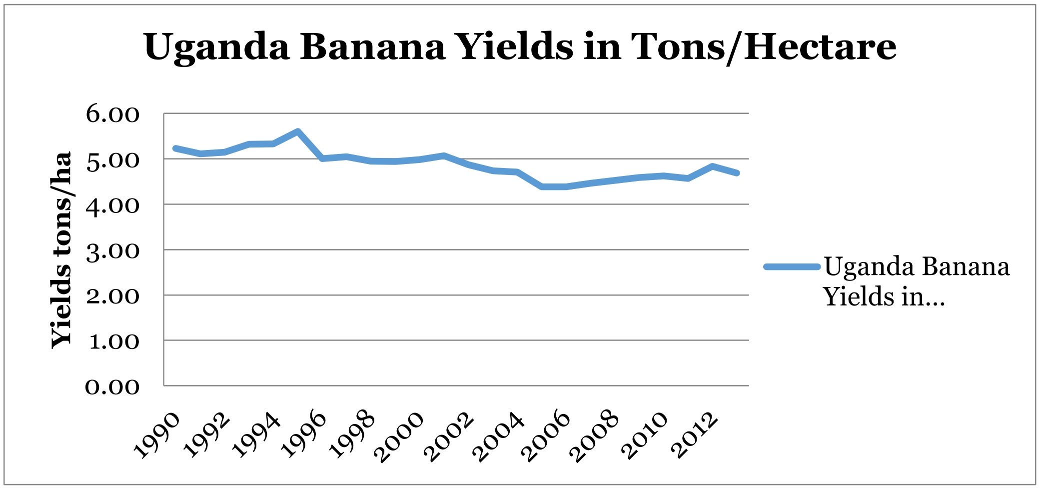

Figure 1 Uganda Banana Yields in Tons/Hectare Source: FAO STAT

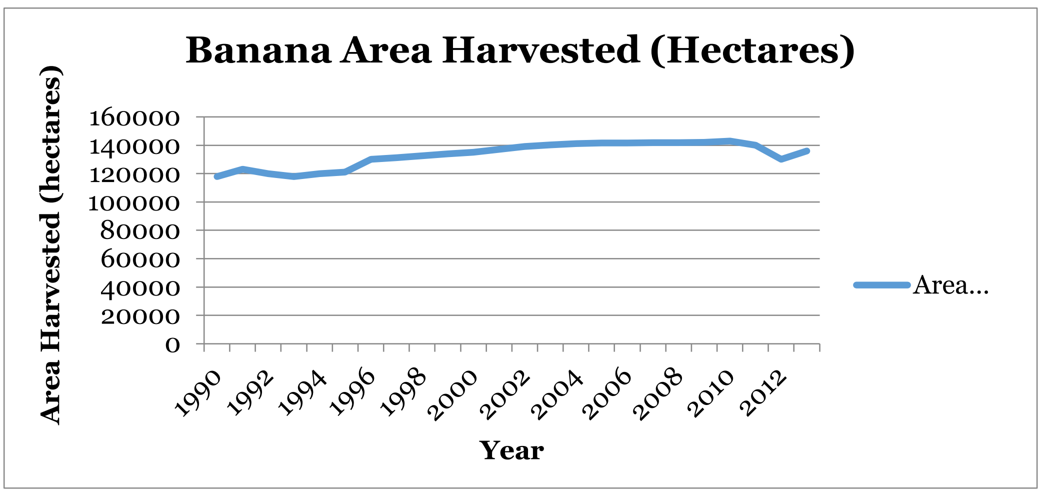

Figure 2 Banana Area Harvested (Hectares) Source: FAO STAT

Banana is an important crop to consider in gender research because it is assumed to be a male's crop (Kasente et al. 2002), even though women have responsibilities in cultivation and processing of banana crops. In Uganda, women provide approximately 80% of the labor in agriculture for food crops, and 50% for cash crops (Kasente et al., 2002), and provide labor in weeding and harvesting in banana cultivation (ibid). This assumption stems from women being seen as responsible for providing food security for the household, whereas a man is involved in producing cash crops and marketing the harvest (Doss 2001; Meinzein-Dick 2014).

As mentioned above, bananas are important for the livelihoods of farmers in Uganda. In Uganda bananas are classified into four simple groups: cooking, dessert, roasting, and beer. From these different types of bananas, many different products can be made and sold, with different market values. The decline of banana production due to pests and diseases has changed farmers' practices, such as pesticide and fungicide application. Treating bananas for pests and disease is done through fungicides or removing diseased plants (Edmeades, 2003; Craenen, 1998), which could be costly for the farmer. Women farmers, especially those in female-headed households are typically more impoverished, and thus more vulnerable to decrease in yields or added costs (Elabor-Idemudia, 1991; Gladwin et al., 2003). Many find that additional incomes sources are required, or experience food insecurity.

There is little information in the adoption of improved seed varieties literature on banana production. This lack of scholarship on banana could be due to banana not considered a "cash crop", which for Uganda is coffee, tea, cotton, and tobacco (Uganda Bureau of Statistics, 2014). However, banana cultivation provides livelihoods and food security for millions of Ugandans.

Increased banana productivity would lead to increased food security, well-being, and improved livelihoods.

2.1 Improved banana varieties

The varieties that are the focus of this paper are improved cultivated varieties, cultivars, which are cultivated and disseminated by the National Agricultural Research Organization-Uganda (NARO), International Institute of Tropical Agriculture (IITA), and Bioversity International. These new improved varieties are bred to resist pests and diseases that have plagued Uganda's banana yields. These diseases require expensive treatments, like fungicides, to prevent the spread, which is not feasible for subsistence farmers (Ploetz, 2001). In some cases, species have developed resistance to fungicides. Developing new varieties that are resistant to pests and diseases is the best option to improve crop yields that have been affected, because it requires little change to farmers' practices.

Improved varieties have already been released to farmers that have higher yields, resistance and tolerance to diseases, pests, and drought (Karamura D.A. et al. 2012), such as the FHIA cultivars. Further work is being conducted by plant breeders at NARO and IITA to develop cultivars that will be pest and drought resistant and include characteristics that are desired by farmers in banana varieties.

New varieties also pose a challenge to subsistence farmers. Improved cultivars are not always accessible to farmers because they are grown and at certain NARO banana farms throughout Uganda. Once the new varieties are obtained, the farmers will not have to change their current system of cultivation. However, when improved cultivars are harvested, there is a risk their market value will not be comparable to other varieties, which could impact the livelihoods of farmers who depend on banana as a source of income.

Throughout this study, it is important to note that there is an assumption by researchers that improved cultivars are better than existing cultivars and should be adopted (Doss, 2006). This assumption leads to the misunderstanding of key variables and constraints that affect adoption decisions. Recognizing this assumption can lead to greater understanding of agricultural production, and how improved cultivars may be one component to improving productivity (ibid).

3. Methods and Methodology

The data in this paper was collected in summer 2015 as part of the baseline survey for the five-year Bill and Melinda Gates Foundation, and Roots, Tubers and Bananas funded project, “Improvement of Banana for Smallholder Farmers in the Great Lakes Region of Africa”. Data collection was both quantitative and qualitative, and included household questionnaires and focus group discussions. Data was collected in a sex-disaggregated fashion with men and women in households interviewed separately. Focus Groups Discussions were both mixed and single sex. Following this method allows for nuanced gender disaggregation, to better analyze the gendered aspects of decisions. Collection took place in 18 villages in two districts, Luwero and Mbarara (Figure 3). Random sampling was conducted at the sub-county, village and farmer level with the assistance of the District Agriculture Officer and local community leaders.

The two districts have distinct features. Luwero is located in the central region of Uganda, 64 kilometers outside of Kampala. Luwero has a population of 458,158, with 79% as rural residents (Uganda Bureau of Statistics 2014). Luwero district is farmlands with rainfall greater than 1,200 mm/year (Wasige, 2009). Mbarara is located in the western region of Uganda, about 267 kilometers outside of Kampala and 57 kilometers from the Tanzanian boarder. Mbarara has a population of 474, 144, with 59% as rural residents (ibid). Mbarara is grass-farmlands with low to medium rainfall (900-1,200MM/year) (Wasige, 2009).

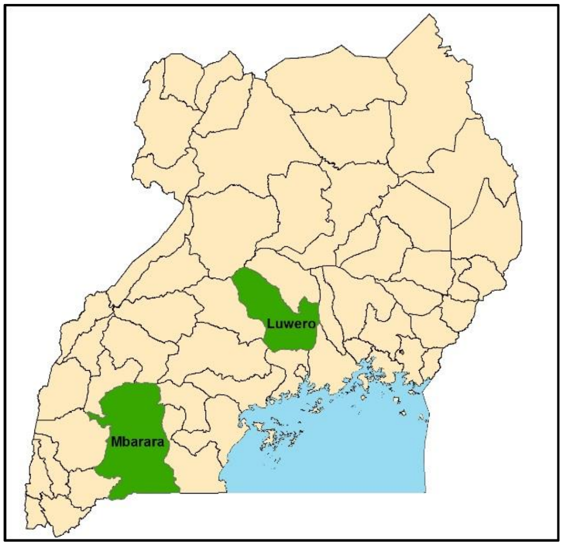

Figure 3 Uganda with two study districts, Luwero and Mbarara highlighted

In total, 488 farmers were interviewed in the household survey, with 200 (41%) men and 288 (59%) women. Men identified as 154 (77%) married monogamously, 18 (9%) married polygamous, 11 (5.5%) cohabitating, 8 (4%) single, 6 (3%) divorced and 3 (1.5% widowed). The women identified as 188 (65%) married monogamously, 38 (13%) widowed, 28 (10%) married polygamous, 23 (8%) divorced, and 11 (4%) cohabitating. These figures can be seen in Table 1.

Table 1 Descriptive Statistics of marital status of participants

Marital Status	Men	Women
Married monogamous	154 (77)	188 (65)
Married polygamous	18 (9)	28 (10)
Divorced	6 (3)	23 (8)
Widowed	3 (1.5)	38 (13)
Cohabitating	11 (5.5)	11 (5.5)
Single	8 (3)	0 (0)
Total	200	288

In the analysis of the study I draw heavily on Doss & Morris (2001) for the analytical framework. In their research, Doss & Morris investigate the gender influences on the adoption of improved maize agricultural technologies in Ghana using key variables to understand the relationship and constraints between female farmers and the adoption decision. Similar to their study, a probit model is constructed to predict the probability of a farmer adopting an improved variety. The results will be analyzed and significant variables will be considered to understand the adoption decision process. To add to the analysis of significant variables in the adoption decision process, key factors found in the literature will be further analyzed to determine possible constraints between male and female farmers, and those living in male-headed households (MHH) and female headed-households (FHH). Farmers in a household can have different preferences and access to resources that will affect adoption decision processes (Meinzen-Dick et al., 1997; Quisumbing & Maluccio, 2003). To more thoroughly analyze the data, it was disaggregated by gender and household headship. As marital status is a socially constructed relationship that leads to differences in decisions and rights (Van Aelst & Holvoet, 2016), it is important to distinguish between women who live in a male-headed household and female-headed households. Women in a male-headed household are participants who identified as married monogamously, married polygamous, and cohabitating. Women in a female-headed household are those who identified as single, widowed, divorced, or their husbands are migrant workers. The data was disaggregated this way in order to accurately distinguish the differences in adoption that are formed from the socially constructed relationship between genders (Quisumbing, 1996; Oakley, 1972).

To keep in mind, this study will work to successfully find significant variables in the adoption decision but it is difficult to determine how a new variety will be adopted *a priori* because the dynamics are very complex (Doss & Morris, 2001).

4. Model

The quantitative data collected through the household survey is the main focus of this paper. The household survey captured details on the farmer, household, plots in the household, livestock, current bananas cultivation and varieties not grown any longer, planting material source, personal income, and agricultural extension participation. The purpose of this survey was to gain a better understanding of those farmers in areas where the new varieties will be tested and over the course of the study to indicate how bananas impacted farmers in the two districts, Luwero and Mbarara. Once the data was collected it was then sorted by selecting participants that identified farming as their main occupation. Correlation tests were run in STATA to detect multicollinearity between the variables.

The probability will be predicted by using a probit model, with information about improved varieties farmers are currently growing. Using a probit model, or a similar model (tobit or logit), has been utilized as a common method in determining the probability of a farmer adopting an improved technology (Doss & Morris, 2001; Feder, 1993; Chirwa, 2005; Adesina &Chianu, 2002; Gerhart; Nerlove & Press, 1976; Adesina & Zinnah, 1993; Adesina and Baidu-Forson, 1995; Akudugu et al., 2012). A probit model can determine a relationship between key variables and probability of adoption (Feder, 1993). Again this approach follows Doss &Morris (2001), which identifies significant key variables in the adoption decision. This model will be used to determine the probability in the study districts, but will not be able to predict the probability of adoption for improved varieties for all of Uganda because the data is limited to Luwero and Mbarara.

The basic probit model used is the following:

Equation 1 Adoption decision probit model

$$Adoption = B_1 + \sum_{i=2}^{n} B_i X_i$$

Where *Adoption* is equal to one (1) the choice to adopt is made, and zero (0) otherwise. A probit model uses a cumulative distribution function of the standard normal distribution (Allbright, 2015). β_1 is the constant of the equation and $\sum\beta_2 X_i$ will comprise the coefficients multiplied by the independent variables. The independent variables are key factors found in the literature that will help to determine the adoption decision, and are discussed in detail in the next section.

5. Constructing the adoption variables

In the adoption equation there are variables that are expected to affect the adoption of improved varieties. These variables were found throughout the literature to be important in the adoption decision of improved agricultural technologies.

5.1 Adoption variable

The rate of adoption between male and female farmers is considered first in order to construct the dependent variable in the probit model. First, who is an adopter in this analysis should be defined. An adopter in this analysis is a farmer who has chosen to grow improved varieties, and possibly grows local varieties as well. This dichotomous approach was chosen due to this baseline data, and interest in the probability of a farmer growing improved varieties.

The bananas varieties that are introduced include the FHIA species that was discussed in Section 2 and other introduced varieties. The rate of adoption of those varieties is considered. Table 2 displays that men tend to grow more introduced bananas than women, and less than 1% for all groups grows solely introduced bananas. Examining those farmers that solely grow introduced bananas is important because is indicates farmers do not have all their production and/or consumption needs met with specifically growing introduced varieties.

Table 2 Local and Introduced bananas varieties grown (number, percent)

Banana Varieties Grown	Men	Women	Women in MHH	Women in FHH
Local	173 (98)	211 (88)	162 (87)	49 (92)
Introduced	69 (39)	75 (31)	59 (32)	16 (30)
Only introduced	1 (1)	1 (0.4)	1 (1)	0 (0)
No decision powers	2 (1)	27 (11)	23 (12)	4 (8)

This analysis will only consider farmers who are or are not growing introduced cultivars. To complete the data for the analysis, farmers who do not have decision-making power over crop types were not considered, because they have not made decisions on the banana varieties to be planted on their household plots. All other farmers are categorized into growing or not growing introduced cultivars (Table 3).

Table 3 Determining adoption dummy variable

Growing or Not Growing Introduced Cultivars	Men	Women	Women in MHH	Women in FHH
Not growing	105 (60)	137 (65)	104 (64)	33 (67)
Growing	69 (40)	75 (35)	59 (36)	16 (33)
Total	174 (100)	212 (100)	163 (100)	49 (100)

5.2 Farmer characteristics

In the probit model, descriptive variables for the farmers will be included. These variables are independent variables that will add to the depth of the analysis.

Gender of the farmer is represented as a dummy variable in the equation. Including the gender of the farmer acknowledges the individual behavior of the farmer and not just the household (Doss & Morris, 2001), again, an important factor in gender-disaggregated analysis. Household headship of the farmer will also be included as dummy variables for male-headed households and female-headed households.

The farmer's age is included in the probit model. Age of a farmer has been found to be significant in adoption studies (Adesina & Baidu-Forson, 1995; Akudugu et al., 2012), which makes it an essential variable to incorporate.

The district of the farmer will be represented by a dummy variable. The district of the farmer could lead to differences in the resources available and accessed, and potentially have different cultural practices and values that could lead to differences in the adoption decision.

The final farmer characteristic variable included in the probit model is the education of the farmer. Multicollinearity was found between the education levels, thus a dummy variable was created if the farmer has or has not completed any education.

5.3 Land Tenure

Land ownership and tenure between genders is a critical variable to understand and include in the probit model. In Uganda, a range of statistics have been reported for land ownership, they range from 10-17% of women and 20-47% of men who solely own plots of land (Kes et al., 2011; Deininger & Castagnini 2006) and 14% of women and 20% of men who jointly own plots of land (Doss et al., 2013).

Land ownership creates an enabling environment for livelihoods and agricultural development. The amount of land a farmer has access to provides information on other important factors, such as credit, capacity to assume risks, access to other resources and information and wealth (Feder, 1993). Farmers that own land rather than renting have also been found to be more likely to adopt a new technology (ibid). Banana is a perennial crop that can have longevity, in considering land ownership and land over which farmers have decision making powers on could highly impact a new variety's adoption process.

In Uganda, land tenure security is a challenge for women. Land ownership is vital for adoption of agricultural technologies, as farmers with secure rights are more likely to undertake resource intensive adoption practices (Muyanga, 2008). The Uganda 1964 Succession Act states that women receive 15% of their deceased husband's land, while the next living male descendant receives the remainder of the land. If a widow remarries, they will lose the right to the land that was left by the husband (De la O Campos, 2016). Ugandan women are statistically less likely to have titles to the land they have access to (ibid), and less than 10% of women's land is titled/documented (Doss et al., 2013).

Land tenure will be represented in the probit model by the amount of land that is owned by the farmer.

5.4 Decision-making

In addition to land ownership, decision-making powers over crop type affects the adoption process. The decision-making power over land is analyzed separately from land ownership, because farmers can have decision-making powers on land they do not own. Decision-making in the household is important for resource allocation and agricultural practices (Doss, 2001), and is "based on men and women's different entitlements and bargaining power" (De la o Campos, 2016, 18; Goldstein & Udry, 2008).

There is a lack of literature that considers the decision-making powers of a farmer, instead assuming the decision-maker is the head of the household (Doss, 2004). Doing so creates a gap in understanding decision-making powers in a household, and the gendered dynamics of decision-making.

The decision-making variable will be expressed as a dummy variable that disaggregates whether the farmer has joint or sole decision-making. As stated above, the participants with no decision-making powers were excluded from the analysis.

5.5 Labor Availability

Labor availability is a determining factor in adoption of new varieties because women are more sensitive to labor requirements, and the labor that is available to them forms what crops and varieties they grow (Croppenstedt, 2013; Von Braun & Webb, 1989). New varieties could require land to be cleared, or require more work, making it important for the household to have access to labor to do so. As discussed, women provide more labor in agriculture than men, and in Uganda, this mostly consists of weeding and processing crops (Kasente, 2002). Men on the other hand are responsible for clearing land and other labor-intensive practices. Therefore, looking at the household composition will help gain a perspective on the labor that could theoretically be available to them.

The baseline data neither shows how labor is allocated within the household nor its gendered dimensions. Increased productivity from a new banana variety may increase labor for a member in the household and reallocate the responsibilities (Doss, 2001). Women face labor constraints from other responsibilities in the household like childcare and domestic work that could impede them from having the ability to perform increased agricultural work (Meinzein-Dick, 2014). This would particularly be a problem for females in female headed-households. New technologies could also have characteristics that make processing the banana more difficult and time consuming for women in the household. An example is a harder peel on the banana, which would increase the time to peel the banana and thus add more time for preparing meals for women (De la O Campos et al., 2016).

Labor availability will be measured by disaggregating household labor by the number of men in the household, the number of women in the household and the number of children in the household.

5.6 Planting material source

Banana plants have several different types of new planting material, such as suckers, tissue culture, and macro-propagated plantlets. In this study 100% of farmers propagated new bananas through suckers, and 8% of farmers relied on tissue cultures. No farmers reported using macro-propagated plantlets. Therefore only the use of suckers was considered as part of the analysis for the probit model.

Where farmers obtain their banana suckers could be determined by cost, accessibility, and reliability of variety types from trusted sources. This information would be vital to determine how to best disseminate suckers of the new banana variety into communities in order to reach all farmers equitability.

Sucker source is represented by a dummy variable that indicates if the sucker was obtained from an external or internal source. External sources include agricultural extension services, private business, and other sources. Internal sources are considered households and other community members. The data was disaggregated this way because 100% of the participants identified as obtaining suckers from either their households or community members, which indicates those sources are not telling indicators for adoption of improved banana cultivars.

5.7 Agriculture Extension Services

Agricultural extension services are an important tool for distributing information and technologies (Meinzein-Dick, 2014), and participation in extension services can affect the adoption of new agricultural technologies (Doss & Morris, 2001). Overall, women farmers are less likely to participate in extension services (FAO, 2011).

Women farmers participating less in agricultural extension services than men farmers could be due to several factors, including time commitments, their role as farmers not taken seriously, and lack of women extension officers (ibid). Women have many responsibilities in a household, such as childcare, cooking, cleaning, and processing of crops. If extension services are at a time of day or season where the women are busy, there might not be time for them to participate in extension programs. Often, men extension officers do not consider women as part of the farming community, and programs are not designed for them, or the officer does not reach out to include women. This could be due to the assumption that women are not decision-makers in the household (Croppenstedt, 2013). As well as, the fact that in some cultural contexts women are more comfortable speaking to an officer of the same gender (FAO 2011; Doss 2001).

Agricultural extension services will be represented by a dummy variable if the farmer has/has not participated in extension services in the past three years.

6. Results and Discussion

The results from the empirical model are seen in Table 4. The results display the significant variables in the decision to adopt improved banana varieties. In the model, gender is not statistically significant, but other predictor variables are. The variables that are significant in the adoption decision are 1) district, 2) age of the adopter, 3) education and 4) obtaining a banana sucker from an external source. Some variables that were expected to have statistical significance did not, such as land ownership, decision-making powers, labor availability, and agricultural extension.

Now that the significant variables in the adoption of new banana varieties have been established, they can be deconstructed to determine if there is a difference in each variable between men and women farmers.

Table 4 Results from probit model on adoption of improved banana cultivars

	Coefficient	Standard Error
Farmer Characteristics		
Gender	0.117	0.175
Head of Household	-0.182	0.279
District	-1.06	0.156***
Age	0.011	0.006*
Education	0.504	0.223**
Land		
Ownership	-0.008	0.008
Decision-making powers	-0.010	0.159
Labor Availability		
Men in HH	0.026	0.074
Women in HH	0.105	0.101
Children in HH	0.027	0.036
Planting source		
External Source	0.609	0.280**
Ag Extension		
Participation	0.038	0.154
Constant	-0.984	0.436
-2 Log likelihood	-210.1283	-210.1283

*Significant at the 0.10 level

**Significant at the 0.05 level

***Significant at the 0.01 level

6.1 District

District is a significant variable in the adoption decision at a 99% confidence level. It is negatively related to the adoption of improved banana cultivars, which implies that farmers in the Luwero district are more likely to adopt improved cultivars. To determine the odds, the exponential function of the coefficient for the district variable was calculated, and for participants living in Mbarara the odds are decreased for adopting improved banana cultivars by 0.34 (Appendix I). This could be due to factors such as more access to different banana varieties, and/or better access to markets due to the proximity of Luwero to the capital, Kampala and NARO. Table 5 breaks down the farmers in each district and shows that more of the participants live in Mbarara district, but more men farmers live in Luwero, 47%, than women farmers. Farmers in Luwero are more likely to adopt improved banana cultivars, thus this is a constraint for women farmers living in Luwero.

Table 5 Participants in two study districts, Luwero and Mbarara (number, percent)

District	Men	Women-All	Women in MHH	Women in FHH
Luwero	81 (47)	75 (35)	54 (34)	21 (42)
Mbarara	92 (53)	137 (65)	108 (66)	29 (58)
Total	173 (100)	212 (100)	162 (100)	50 (100)

6.2 Age

Age is a significant factor in the probit model at a 90% confidence level. Age is positively related to the adoption of the improved banana cultivars, and this implies that older farmers are more likely to adopt. Again, the odds of a farmer is calculated by taking the exponential function of the coefficient and for every year of age added to a farmer the odds of that participant adopting improved banana cultivars increases by 1.01 (Appendix I). From Table 6, it can be seen that men farmers are on average older, however, women in female-headed households have the highest average age. This would indicate that women in female-headed households in more likely to adopt improved cultivars because on average they are older in age.

Table 6 Descriptive statistics of age of participants

	Men	Women-All	Women in MHH	Women in FHH
Average Age	47	41.3	38	54
Standard Deviation	14.6	13.8	12.1	12.0

The significance of age could be due to older farmers being capable to handle more risks, access to land, and having more social capital than younger farmers. However, gender or household headship does not seem to be a constraint in the adoption of improved banana cultivars on the average age of farmers in Table 6.

6.3 Education

Education is significant in the probit model at a 95% confidence level. Education is positively correlated with the probit model, which indicates that farmers who have had education are more likely to adopt improved banana cultivars than farmers who have not had any education. The odds of a farmer adopting improved banana cultivars is increased by 1.65 more than farmers who have not had any education.

There is a strong relationship between education and farm productivity. Adoption of new agricultural technologies increases farming productivity (Kasente, 2002), and is very important in understanding new technology, and even more so when extension services are minimal (Huffman, 1977). In Table 7 the education level completed is disaggregated by gender and head of household, and shows that education patterns are different between gender and head of household. A higher percentage of women, especially in female-headed households, have no education compared to men farmers. This inequality in education between gender and head of households is a constraint to the adoption of the improved banana cultivars, and should be considered when new cultivars are introduced to farmers.

Table 7 Level of Schooling for farmers (number, percent)

Education level completed	Men	Women-All	Women in MHH	Women in FHH
None	14 (8)	45 (19)	30 (16)	15 (28)
Primary	120 (68)	161 (67)	127 (68)	34 (64)
Secondary	30 (17)	31 (13)	28 (15)	3 (6)
Post Secondary	12 (7)	2 (0.8)	1 (0.5)	1 (2)
Total	176 (100)	239 (100)	186 (100)	53 (100)

6.4 Planting material source

Planting material source is a significant variable in the adoption decision at a 95% confidence level. It is positive, which indicates that farmers who obtain their banana sucker from a source from a NGO, private business, or agricultural extension service, or another outside source are more likely to adopt improved varieties. The odds of a farmer adopting an improved variety if the sucker is from an external source are 1.84 higher than if the farmer obtained the sucker from an internal source. Table 8 disaggregates where farmers are obtaining their banana suckers. Farmers could respond with all sources of sucker planting materials, so some respondents are in both categories. Table 8 shows that more women than men obtain their suckers from agricultural extension services, and more men obtain their suckers from private businesses than women. These descriptive statistics indicate the trust and/or confidence that men and women have in particular external sources. Women trust the agricultural extension services to obtain new varieties, but men are more likely to trust private businesses in obtaining their new banana varieties. A conclusion can be drawn from this difference in trusted sources, by examining the social networks of men and women farmers. Men farmers usually have social networks that extend outside of the community, such as bars or markets. On the other hand, women farmers are more likely to have social networks within their own communities (Katungi et al., 2008). Thus, women farmers are more likely to trust sources in their social networks, such as agricultural extension services that have programs in their community, and men in theirs, such as private businesses. Knowing this distinction is important in order to equally disseminate improved banana varieties to men and women farmers.

Table 8 Banana sucker planting source for participants (number, percent)

	Banana sucker planting source	Men	Women-All	Women in MHH	Women in FHH
Internal	Household	160 (92)	212 (100)	162 (100)	50 (100)
	Community	71 (40)	135 (56)	105 (56)	30 (57)
External	Ag Extension	4 (2)	9 (4)	8 (4)	1 (2)
	NGO	1 (0.6)	0 (0)	0 (0)	0 (0)
	Private Business	8 (5)	8 (3)	8 (4)	0 (0)
	Other	2 (1)	1 (0.4)	1 (1)	0 (0)

6.5 Methodological Caveats

This study shows that not all the key variables in adoption decisions for improved agricultural technologies as indicated in the literature are significant in this study. However, other studies with similar models did find these variables important. In this analysis it must be asked, why are not all the decision variables significant?

One explanation could come from the variables themselves. Most of the variables that were used in this analysis were not significant for improved banana adoption, so investigating the variables that are important could lead to a more explanatory model. Such variables could include access to markets and available credit, which were not included in the baseline survey.

Multicollinearity of the data could also affect the significance of the variables. Multicollinearity refers to the instance when the independent variables are trying to predict the same variance in the dependent variables. If there is great overlap then there is high correlation, or multicollinearity (Gujarati, 1999; Ratick, 2015). Multicollinearity was tested for, but it could still affect the calculations made about individual predictors, and make the variables sensitive to changes in the model (Farrar & Glauber, 1967). Figure 4, the Ballantine view of multicollinearity best explains this.

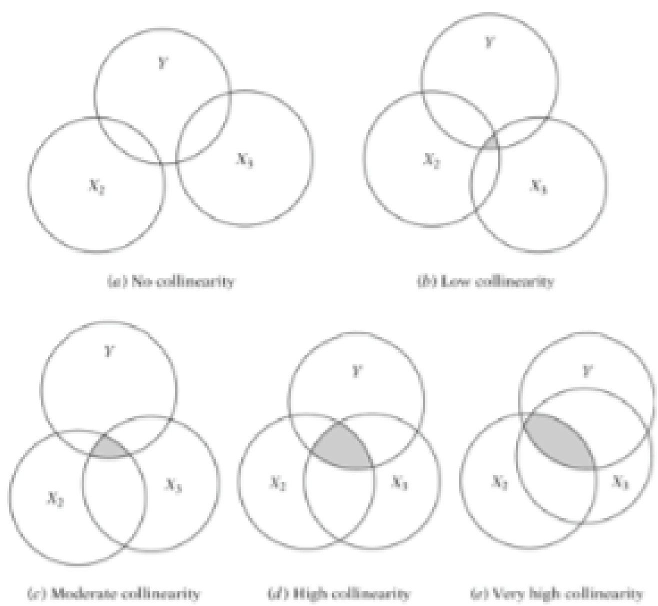

Figure 4 Ballantine Explanation of Multicollinearity Source: Gujarati, 2012

Finally, this analysis was conducted based on an already introduced variety that will not be part of new trails scheduled for 2017. This fact could lead to differences in the significant variables. However, the purpose of this study is not test for the adoption of a particular improved variety, but for factors that effect adoption decisions, in general.

7. Conclusion

In this analysis, conclusions about variables that influence the adoption decisions in the sample districts have been drawn. First, the probit model concluded that neither gender nor household headships are significant variables in the adoption decision for improved banana cultivars. However, the probit model did determine that district, age, education and planting source were significant factors. Second, when the significant factors were disaggregated between males and females and head of households, differences and patterns were found in the variables for district, which show constraints for female farmers in the adoption of improved banana cultivars.

All the findings are important to consider for the study because it could have an impact on the adoption of the new improved banana varieties, as well as future research studies on improved banana cultivars in Uganda and policy implications. Correct analysis of sources of adoption differences is important in order to identify policy interventions to increase women's productivity (Quisumbing, 1996).

While this study did not find that either gender or head of household specifically influences a farmer in improved banana cultivar decision, is it still important to examine the context in which the technology is implemented for successful adoption by both men and women farmers (Doss & Morris, 2001). Men and women have different preferences and constraints that lead to the adoption decision, and these must be understood in order to successfully implement improved technologies. This study also brings to light an imperative concept; not everything can be known about a project beforehand and a specific development model can be applied to all locations.

This study highlights areas where policy and research could be developed to increase the successful adoption of improved banana cultivars in Uganda that could lead to higher agricultural productivity. Increased agricultural productivity in Uganda would lead to increased food security and wellbeing, as well as improved livelihoods for all. Nevertheless it is imperative to keep in mind that identifying the factors that lead to the adoption decision of improved banana cultivars is key.

8. Acronyms and Abbreviations

NARO	National Agricultural Research Organization
IITA	International Institute of Tropical Agriculture
FHIA	Fundación Hondureña de Investigación Agrícola
MHH	Male-headed households
FHH	Female-headed households

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10. Appendix I

Table 9 Odds of farmers adopting improved varieties by taking the exponential function of the coefficient

Variable	Odds	Comments
Gender	1.1	Women are more likely to adopt
Head of Household	0.8	Farmers in MHH are more likely to adopt
District	0.3	Farmers in Luwero are more like to adopt
Age	1.0	Older farmers more likely to adopt
Education	1.7	More educated more likely to adopt
Acquired Land	1.0	Farmers with more land more likely to adopt
Decision making powers	1.0	Farmers with more decision making powers more likely to adopt
Men in the HH	1.0	More men in the HH more likely to adopt
Women in the HH	1.1	More women in the HH more likely to adopt
Children in the HH	1.0	More children in the HH more likely to adopt
External Planting source	1.8	Farmers obtaining suckers from external source more likely to adopt
Ag Extension	1.0	Farmers participation in ag extension more likely to adopt